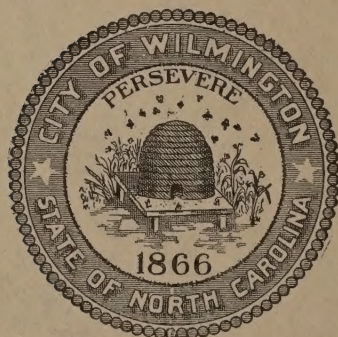


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THE NORTH CAROLINA GEOLOGICAL AND
ECONOMIC SURVEY

JOSEPH HYDE PRATT, State Geologist

ECONOMIC PAPER No. 15

THE MINING INDUSTRY

IN

NORTH CAROLINA DURING 1907

WITH

SPECIAL REPORT ON THE MINERAL WATERS

BY

JOSEPH HYDE PRATT, Ph. D.



RALEIGH

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LETTER OF TRANSMITTAL.

CHAPEL HILL, N. C., October 15, 1908.

To His Excellency, HON. ROBERT B. GLENN,

Governor of North Carolina.

SIR:—I herewith have the honor to submit for publication, as Economic Paper No. 15, a Report on the Mining Industry in North Carolina for the year 1907, with a special report on the Mineral Waters of the State.

Yours respectfully,

JOSEPH HYDE PRATT,

State Geologist.

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OPEN PIT AT THE SHUFORD MINE, CATAWBA COUNTY, N. C. AUTOMATIC SCRAPER NEAR TOP.

MINING INDUSTRY IN NORTH CAROLINA DURING 1907.

BY JOSEPH HYDE PRATT.

INTRODUCTION.*

Notwithstanding the fact that the last six months of the year 1907 were marked by a financial panic and general business depression, there was a decided increase in the total value of the mineral production in North Carolina during the past year over that of the previous year. There were two mineral products, building stones and clay products, that it was expected would show a considerable falling off in value, as they are so dependent upon building industries, which were seriously affected by the business depression. Both these products, however, showed a decided increase in the value of their production as compared with the previous year. With the increased demand for timber and the corresponding gradual but constant advance in price for this building material, there is a growing demand for other forms of structural material, as brick, sand-lime brick, granite, limestone, etc. This will cause an additional increase in the production of such materials beyond that ordinarily expected from the regular increase in construction work in a State.

Of the metallic minerals, there was a slight increase in the production of iron, but a decided decrease in the production of gold, silver and copper. This latter decrease was due to the sharp decline in the price of copper during the latter half of 1907, which resulted in the closing down of nearly all the copper mines in the State.

Of the non-metallic minerals, there was a slight increase in the production of mica, for which North Carolina is especially noted, and in tale and soapstone. The production of monazite, however, which had been steadily increasing up to the past year, showed a very large decrease, which was due to the low value of thorium nitrate, which is the commercial salt derived from monazite.

On the whole, however, the results of 1907 show that the mining and quarrying industries of the State are in a most prosperous condition and that, although some of them are developed to but a slight degree of what they are capable, they are yet in such a condition that such further development is practicable. One of the greatest influences

*The North Carolina Geological and Economic Survey has co-operated with the United States Geological Survey in the collection of the mineral statistics used in this report.

that has reacted in favor of the development of the various minerals of the State has been the more systematic advertising of the mineral resources not only by the State bureaus, but also by the individuals and corporations owning the mines and quarries.

There are many favorable forms of investment that can be made in this State in mineral properties, some of which would necessitate the establishment of manufacturing plants either at or close by the mineral deposit in order to utilize the mineral and convert it into a commercial product. This is especially true of certain of the clay deposits.

There is one point that must be taken into consideration in connection with mining or prospecting for minerals in North Carolina, and that is that the State is a well settled, farming one and there are no State or Federal lands which offer special privileges or inducements to prospectors, as is the case in the west where mineral and mining claims can be taken up on the Federal domain. The only land belonging to the State is certain areas of swamp lands in the extreme eastern portion of North Carolina. It is also often difficult to make satisfactory arrangements with the property holders for prospecting, and propositions for such work from outsiders are often regarded as an intrusion and with suspicion. For these reasons it is more difficult to locate good properties, and many valuable mineral deposits have been the result of the accidental finding of the ore.

In connection with the work of the North Carolina Geological and Economic Survey, where various sections of the State are being examined by its geologists, any information of value obtained regarding these sections is always given to the landowner before same is published. The members of the Survey staff are always ready and willing to give any assistance and information regarding any mineral property when they happen to be working in the vicinity where such property is located.

The total value of the mineral production of North Carolina* during 1907 was \$3,173,722, as compared with \$3,007,601 in 1906, an increase of \$166,121. The production of 1906 was also a decided increase over that of 1905, amounting to \$568,220, this making a total increase in the mineral production for the two years of \$734,341. In order to show more strikingly the general increase in the value of the various minerals produced in North Carolina for the past five years, there is given in the following table the production of each mineral produced in the State from 1903 to 1907 inclusive.

*In the collection of the production of the various minerals, the State Survey has had the cooperation of the Department of Mineral Resources of the United States Geological Survey.

THE MINERAL PRODUCTION IN NORTH CAROLINA FOR THE YEARS 1903-1907.

Mineral	Value.				
	1903.	1904.	1905.	1906.	1907.
Gold	\$ 113,604	\$ 123,924	\$ 129,153	\$ 122,008	\$ 82,195
Silver	16,907	19,132	20,216	30,944	14,299
Copper	67,037	36,600	88,000	135,829	116,416
Iron	78,540	79,846	70,352	75,638	113,488
Pyrite					
Garnet					
Corundum	12,250	6,586	9,000		13,500
Millstones	902	6,500	2,652	4,110	1,969
Mica Sheet	86,300	100,724	100,900	205,756	209,956
Mica Scrap	2,400	3,410	3,375	11,940	15,250
Quartz	36,827	36,269	13,659	12,578	1,664
Precious stones	1,625	10,600	3,350	5,000	7,580
Rare minerals	270	160			9,300
Monazite	58,694	79,438	107,324	125,510	54,824
Zircon	570	200	1,600	248	46
Barytes	21,347	33,930	21,670	10,020	18,855
Talc and pyrophyllite	76,984	65,483	74,940	66,979	74,347
Mineral water	13,085	21,902	38,755	31,413	40,302
Graphite	248	525	475	475	
Coal	25,300	8,820	2,336		
Stone	360,322	312,576	597,922	854,301	956,919
Sand and gravel			547	9,191	2,191
Sand-lime brick		17,500	29,103	32,975	38,808
Kaolin	76,000	76,670	85,622	90,036	85,505
Clay products	866,458	944,580	1,038,430	1,182,660	1,316,308
Total value	1,915,570	1,985,675	2,439,381	3,007,601	3,173,722

The following minerals and ores have been mined in North Carolina during 1907 and are discussed in this report in the order given: Gold and Silver; Copper; Iron; Tin; Abrasive Materials (including Garnet and Millstones); Mica; Quartz (Flint); Barytes; Monazite and Zircon; Talc and Soapstone; Precious Stones; Mineral Waters; Graphite; Coal; Peat; Stone (Granite, Sandstone, Marble and Limestone); Sand and Gravel; Sand-lime Brick; Kaolin and Clay Products.

GOLD AND SILVER.

In the report on the Mining Industry for 1906 considerable space was devoted to a discussion of the gold and silver deposits of the State. Many of the properties were described in detail, and there was a full discussion of those changes in mining practice that had resulted favorably to the development and mining of these metals. In the present report only those properties will be described that have been developed to a considerable extent during the past year or are new properties. For location of gold mines, see Fig. 1, which has been reproduced from map of U. S. Geological Survey.

The Iola Mine, near Candor, Montgomery County, continues to be the largest producer of gold in the State. This mine is on a vein that dips about 45° to the SE. and is parallel to the so-called slates, striking N. 55° E. In width it varies from 2 to 8 feet, and has all the appearance of being replacement of the country rock, there having existed previously a crevice or line of fracture which has been enlarged by

solutions and either the country rock directly replaced by quartz or the enlarged fissure has later been refilled. The value of the ore taken out during the past year varies from a few dollars to over \$30 per ton, some places having been opened up that showed a thickness of 8 feet of a soft, white, sugary quartz containing \$30 per ton in gold. In two places the vein has pinched out to a mere stringer which may open up again in a short distance into a vein of sufficient width to mine. The values in the vein are irregular and there are richer shoots of ore, the main one extending from 100 to 150 feet along the vein and continuing from the surface down to the lowest level to which work has been extended, 320 feet on the incline. The values in the lower portion of this shoot are somewhat less than at the upper levels. Besides this main shoot, there are several smaller ones, usually about 30 inches thick in the middle, extending something like 30 feet along the strike. The ore in some of these is composed of sugary quartz with visible gold and others are hard, vitreous quartz with included masses of unaltered slate. Along the contacts of these included masses of slate is occasionally found coarse gold in octahedral crystals up to $\frac{1}{4}$ inch in diameter.

A new 3-compartment incline shaft has just been driven which will become the main working shaft. It will be sunk to a depth of 600 feet, when it is expected it will intercept the vein. All the ore will be brought out of the mine through this shaft and delivered by gravity directly to a new 40-stamp mill that has just been installed. The cyanide plant has also been rebuilt and now there is a considerable saving in cost of production, due to less handling of the ore than when the old stamp and cyanide mills were in use.

Nearly all the coarse gold and much of the fine is amalgamated, the tailings, which vary from \$2 to \$4 per ton, being run to the cyanide plant. These tailings pass first into settling tanks or, as they are called at the mine, sand boats, that are 3 feet wide at one end, 4 feet at the other, 12 feet long and $3\frac{1}{2}$ feet deep (see Pl. II, A). At the small end is a wooden lattice on the inner side of which a canvas curtain may be rolled up from the bottom.

The wet sand from these boats is shoveled out and dumped to one side, where it is allowed to drain and become partly dried. From this pile the sand is wheeled in wheelbarrows over to the sand tanks and dumped. These tanks are 20 feet in diameter, 4 feet deep, and made of yellow pine. There is the usual cocoa-matting filter in the bottom, such as has already been described. They hold, when filled to a convenient height, 40 tons of sand (Pl. II, B). The sand is smoothed off and then the solution of potassium cyanide of .05 per cent strength



A, SETTLING TANKS, IOLA MINE, MONTGOMERY COUNTY.



B, CYANIDE TANKS IN COURSE OF CONSTRUCTION, IOLA MINE, MONTGOMERY COUNTY.

(1 pound of potassium cyanide per ton of water) is poured onto the sand. This solution is kept circulating as rapidly as possible for three or four days. It is usually allowed to drain down until the sand becomes exposed, when it is again filled up. At the end of this time the solution is allowed to drain off, after which a little water is used to displace what solution remains in the damp sand. The first solution is led to the strong gold solution tank and the washings to the weak solution tank. The sand is then washed out by a stream of water from a hose through a door or opening in the side of the tank. The slimes flow from the sand boats to one of three agitation tanks that are 10 feet deep and 20 feet in diameter. Near the bottom of each of these a paddle consisting of four well-braced oak arms carrying pins slowly revolves. A solution of cyanide is permitted to enter the slime tanks at the same time with the slimes. The strength of this solution is such that, combining with the water mixed with the slimes, will make it approximately .05 per cent solution.

The agitation continues while the tank is being filled and at the same time air is introduced by means of a pipe connected with an air compressor. When one of these agitation tanks is filled, the slimes are led to a second and then a third. The process continues until the tank is needed for more slimes. The slimes in solution are then drawn off at the bottom and passed into settling tanks 14 feet deep by 18 feet in diameter at a lower level. Here the solid matter slowly settles out and then the clear solution is drawn off and stored in the weak solution gold tank, from which it is later led to a special set of zinc boxes.

The solution from the sand tank which contains the gold is not stored, but passes directly to the zinc boxes. These have six compartments, $2 \times 2 \times 2\frac{1}{2}$ feet, with a side trough and diaphragm for circulating the solution. This arrangement allows any one box to be emptied and cleaned while the solution circulates through the others. From the zinc boxes the solution flows to a sump tank 10×20 feet, where more potassium cyanide is added to replace what has been consumed, until the solution reaches the right strength. This sump tank therefore serves also for a stock solution tank from which the solution is raised by a small centrifugal pump to the sand-leaching tanks.

The clear solution from the slime-settling tank, which is stored in the weak-solution gold tanks, flows through an 8-compartment zinc box made similarly to the other and then to a sump or weak-solution tank. Most of the gold is precipitated in the first box. Each month the zinc in the box is sifted and the fine stuff saved, while the coarse is returned to the box. The deficiency of coarse zinc in the first box is made up by taking some of it from the second, which is in turn filled from the third,

etc. All the fresh zinc required is added to the last compartment. The fine particles of zinc that are sifted out are saved, as they often contain a coating of gold, and, when the accumulations amount to a sufficient quantity, they are treated and the gold saved.

The gold slimes or finely divided gold containing small scraps of zinc are melted in a graphite crucible, to which a little nitre is added to oxidize the zinc and unite with the borax, which is used as a flux. The melted gold is then cast into bricks and sent to the mint.

Eight pounds of lime are added to each ton of tailings as they are dumped into the sand tanks. A small amount of lime is also added to the slimes as they are running into the slime tank. This ore is very free from other elements that would react on the cyanide solution, with the exception of some acid sulphate formed from the pyrites, which is neutralized by the lime, and therefore the principal loss of cyanide is that wasted with the wet slimes. The tailings from the cyanide plant contain about 50 cents gold per ton.

The next largest producer of gold in the State during 1907 was the Shuford Mine. This mine is situated in Catawba County, $4\frac{1}{2}$ miles slightly south of east of Catawba, a station on the Southern Railway. The mining tract comprises about 425 acres, of which 20 acres is the part that contains the workable mineral deposit. This latter area is covered with auriferous quartz and the soil is also auriferous. The underlying schists and gneisses were found to be penetrated by seams of auriferous quartz which run in every direction. There are, however, no veins, strictly speaking, although some of the quartz seams are several inches in thickness and are persistent for a considerable distance in length and depth. The entire surface for a width of 300 or more feet and for a distance of 1,000 or 2,000 feet is pay material. When the property was first opened an attempt was made to mine the ore by sinking shafts, running drifts and then stoping, but was practically a failure from the start. One shaft was sunk to a depth of 115 feet and several levels started from this and considerable ore stoped out. Although many of the narrow quartz seams contain gold in some quantity, it was too expensive mining this on account of the amount of waste material which had to be removed. About 1904, after the property had been closed for some years, it was bought, principally on account of the depth to which the saprolitic rocks extended and because of their area. It was the desire of the purchasers to test the practicability of a new type of log-washer in saving gold from such saprolitic rocks. As described in Economic Paper 14, page 19, the process was a success. Instead of attempting to mine the ore by stoping and trying



A, SCRAPER IN USE AT THE SHUFORD MINE, CATAWBA COUNTY.



B, OPEN CUT OF THE SHUFORD MINE, CATAWBA COUNTY.

to eliminate the low-grade material, a method of open-pit work was introduced and all the material taken out was treated in the separators.

When this method of mining was first started,* the ore was drawn out of the pit by means of a skip running on a wooden track, which was self-dumping, and discharged on a grizzly at the top of the pit. While this method handled the ore very cheaply, more economy was desired, and finally an ingenious method was devised consisting of self-loading scrapes holding from $\frac{3}{4}$ to nearly 2 tons of ore. See Pl. III, A and B. There are two of these scrapes on an endless wire rope, the loading scrape pulling the empty one back down into the pit. The ore is broken down from the sides of the pit by blasting with powder from 20-foot holes, using 2 to 3 kegs of powder. The material loosened falls in piles at the bottom of the pit. The scrapes, as they are pulled back into the pit, are hauled over this material and then, when started toward the surface, their own weight causes the edge of the scrape to be pulled down into the ore and they are readily filled by the pull of the cable. A scrape can be loaded and dumped in the hopper about every 75 seconds.

The scrapes are 5 feet wide, $5\frac{1}{2}$ to 6 feet long and 18 inches high at the rear, tapering somewhat toward the front end. (See Pl. III, A.) The bottom of the scrape only extends for a distance of about 18 inches, the ore between the balance of the side pieces of the scrape resting on the ground. These scrapes run in a trough or trench in the ground, the steeper portions of which are protected by scantling. (See Pl. III, A, and Pl. I.) As the scrape comes to the top, it runs over a hopper and the mass of ore immediately drops out. A special blade and handles permit the emptying of the scrape in a few seconds.

The hopper is in the shape of a circular trough made of boiler plate into which two streams of water are flowing which are of sufficient volume and strength to wash the ore through a grizzly and then through the concentrating machines. (See Pl. III, A.)

As one can readily see, a profitable method to treat these ores that only carry from 50 cents to \$1 per ton in gold must be simple, economical and thorough. This new separator does its work efficiently, saving approximately 85 per cent of the values, even though the gold may be in a very finely divided state. The principal cost in using this machine is in the mining operations, and the only practical method for mining ores of this type would be by means of open cuts and pits. The entire expense of handling the ore after it has been brought to the hopper should not be more than 15 to 18 cents per ton, and should be reduced even below these figures. One machine consisting of two

*Economic Paper No. 14, pp. 19-26. Log washers, by A. A. Steel and Joseph Hyde Pratt.

washers will handle at least 100 tons of ore in 10 hours, and can be pushed up so as to handle 125 tons. They require only 75 gallons of water per minute and a 15-horse power engine is sufficient to run one machine.

These modern pulverizing and concentrating machines have been installed at the Catawba Mine, at the Laffin Mine near Cox, Randolph County, at the Troy Mining Company's property 7 miles north of Troy, Montgomery County, at the Sawyer Mine in Randolph County, at the Merrill Mine 3 miles west of Sophia, Randolph County, and at the property of the Gold Valley Mining Company at Gold Valley, Rutherford County, 4 or 5 miles from Brindletown.

There were a number of properties in the State at which a great deal of development work was done during 1907, but which made no production of gold or silver. Some of these, as the Sawyer Mine in Randolph County, the Parker Mine in Stanly County, the Pine Hill and Pilot Mountain mines in Randolph County, the Gold Valley Mine in Rutherford County, and the mine at Teer, 8 miles from Chapel Hill, Orange County, will undoubtedly be producers in 1908.

Dredging has been carried on to some extent on the Catawba River by Mr. Edgar L. Brown, of Charlotte, N. C., and near Ransome's Bridge, Halifax County.

Silver.—Nearly all of the silver produced in North Carolina is obtained as a by-product from copper ores, there being but a very small per cent obtained from the gold ores, the North Carolina gold being noted for its fineness. Of the total production of silver, \$14,299, only a few hundred dollars were obtained from the gold ores, the balance being obtained from the copper ores. Thus it is seen that any decided decrease in the production of the copper ores means also a decrease in the production of silver.

PRODUCTION.

The total production of gold and silver during 1907 was \$96,494, coining value, which is a decrease of \$56,458 as compared with \$152,952, the value of the production of 1906. Of this 1907 production, \$82,195 was due to the value of the gold produced, which is a decrease of \$39,813 as compared with \$122,008, the value of the 1906 production. The coining value of the silver produced was \$14,299 as compared with \$30,944, the value of the 1906 production, this being a decrease of \$16,645, and is due to the smaller production of copper.

Montgomery County continued to be the largest producer of gold and Catawba was second. The largest production of silver was from Rowan and the second largest from Person, both of these counties also being the largest producers of copper. In the following table there is

given a rough estimate of the production of gold and silver in 1906 and 1907 by counties, which will illustrate the distribution of the production throughout the State.*

PRODUCTION OF GOLD AND SILVER IN 1906 AND 1907 BY COUNTIES.†

County.	1906.			1907.		
	Gold.	Silver.	Total.	Gold.	Silver.	Total.
Burke	\$ 550	\$ 7	\$ 557	\$ 2,976	\$ 13	\$ 2,989
Cabarrus	17,500	50	17,550	1,521	1	1,522
Catawba	6,600	110	6,710	6,274	45	6,319
Cleveland	1,000	10	1,010			
Davidson	750	300	1,050	386	109	495
Franklin	8	600	608	1,186	2	1,188
Gaston				300		300
Granville				145	2,226	2,371
Guilford	6,500	25	6,525	1,863		1,863
McDowell	800	12	812	222	1	223
Mecklenburg	3,500	15	3,515	7,744		7,744
Montgomery	60,100	1,600	61,600	52,438	410	52,848
Moore				225	1	226
Nash	1,300	5	1,305			
Person	200	8,750	8,950	145	2,226	2,371
Randolph				300		300
Rowan	7,000	19,000	26,000	3,683	9,243	12,926
Rutherford				223	1	224
Stanly	10,000	150	10,150	50		50
Union	5,000	35	5,035	500	21	521
Unknown	1,200	375	1,575	2,014		2,014
Total	122,008	30,944	152,952	82,195	14,299	96,494

*The gold and silver statistics have been obtained through the courtesy of Mr. George C. Roberts, Director of the Mint, Washington, D. C. The counties given in this table do not represent all the producing counties, but the production has been given, as far as possible, of the principal producing counties and the balance is given as "Unknown." This latter undoubtedly includes a dozen or more counties.

†Coining value.

The next table gives the value of the gold and silver produced in North Carolina for the years 1882 to 1907, inclusive:

GOLD AND SILVER PRODUCTION IN NORTH CAROLINA
FROM 1882 TO 1907.*

Year.	Gold.	Silver.	Total.
1882	\$190,000	\$ 25,000	\$215,000
1883	167,000	3,000	170,000
1884	167,000	3,500	160,500
1885	152,000	3,000	155,000
1886	175,000	3,000	178,000
1887	225,000	5,000	280,000
1888	135,000	3,500	139,500
1889	145,000	3,878	148,878
1890	113,500	7,757	126,257
1891	95,000	6,465	101,465
1892	78,560	12,671	91,231
1893	53,600	17,325	70,925
1894	46,594	455	47,049
1895	54,200	520	54,720
1896	44,300	646	44,946
1897	34,600	388	34,988
1898	84,000	905	84,905
1899	34,500	388	34,888
1900	44,653	15,986	60,639
1901	60,410	34,023	94,433
1902	93,650	30,212	123,862
1903	113,604	16,907	130,511
1904	123,924	19,133	143,057
1905	129,153	20,216	149,369
1906	122,008	30,944	152,952
1907	82,195	14,299	96,494

*Coining value.

COPPER.

As stated in the report for 1906, the Geological Survey is making a thorough investigation of the copper mines and copper deposits of the State, and in that report there is a brief description given of the copper areas of Swain County. In the present report a brief description with illustrations is given of the copper belt of Rowan and Stanly counties, known as the Gold Hill District. This investigation has been made by F. B. Laney, assisted by J. E. Pogue, Jr., and under the supervision of the State Geologist.

THE GOLD HILL COPPER DISTRICT.

BY F. B. LANEY.

Location.—The Gold Hill copper district is located principally in the southeastern portion of Rowan County, but includes a portion of the northeastern part of Cabarrus and a narrow strip of the northwestern part of Stanly counties. (See Figs. 1 and 2.) It lies in the south central portion of the State and its eastern boundary is about 35 miles west of the eastern limits of the Piedmont Plateau. It consists of a strip about 18 miles long and 8 miles wide, extending from the Yadkin River on the northeast to near the village of Mt. Pleasant on the southwest, the center of mining, the village of Gold Hill, being located approximately in its center.

The principal surface features of the district are a low-lying, flat-topped ridge, the Gold Hill ridge, which extends from about 2 miles southwest of the village of Gold Hill to and beyond the Yadkin River, and a series of hills, the Beaver Hills, lying between the village and Buffalo Creek. For the most part there is little relief but the hills just mentioned and the northeast portion of the Gold Hill ridge, especially the latter. The Gold Hill ridge forms the watershed of the district. The streams to the northwest of this ridge flow northeast into the Yadkin River and those to the southeast flow southeast into Rocky River. The principal streams are the Yadkin River, which forms the northeast boundary of the district; Second Creek, flowing northeast into the Yadkin River, and Buffalo Creek, which flows southeasterly across its southwestern portion.

The district may be reached by the Southern Railway, the Norwood branch of which crosses it at Gold Hill nearly at right angles. The nearest town of any size is Salisbury, about 15 miles northwest of Gold Hill.

General description of the rocks of the district.—The area is about equally divided between igneous and plastic rocks. The eastern portion comprises the great series of "slates," intercalated in which are irregular

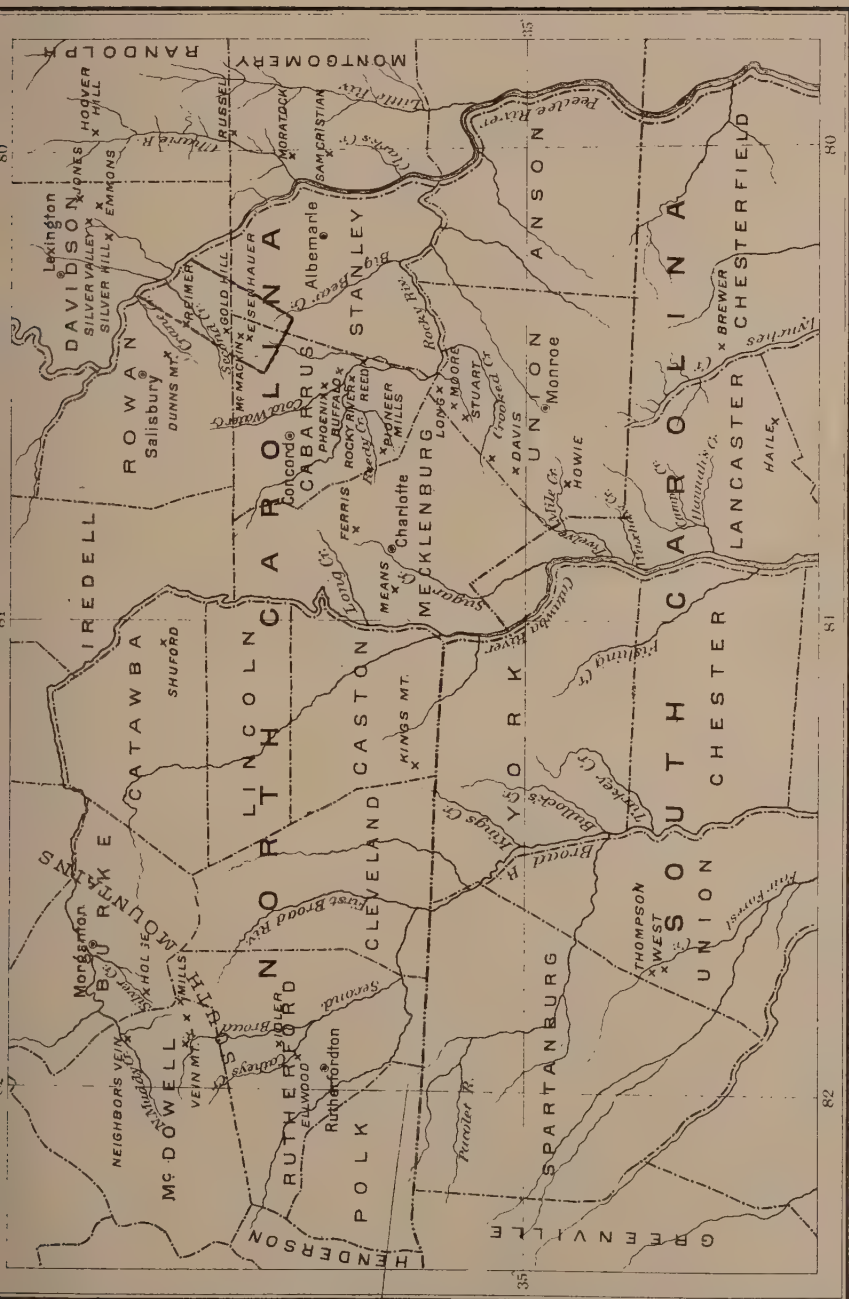


FIG. 1.—*MAP OF CENTRAL NORTH CAROLINA SHOWING LOCATION OF THE PROMINENT COPPER AND GOLD MINES (X).

* Reproduced from Map of U. S. Geological Survey.

bands and long lenses of volcanic rocks representing tuffs, breccias, and flows, of which there are two types—rhyolitic and andesitic. The western portion is made up wholly of igneous rocks. There are three general types—greenstone, diorite, and granite, together with numerous dikes of both acid and basic character. Each type shows more or less variation and local differences. In a general way, it may be said, taking the rocks in order of their relative ages, that the greenstone with its local tuffaceous phases is the oldest and most highly metamorphosed rock in the area, the diorite next in order, and the granite least of all. There are at least four types of rock occurring as dikes, the character of which varies as to the relative time of intrusion. The oldest dikes are those of diorite and are found cutting only the greenstone. Following this series come the granite and quartz-porphyry dikes, which are found cutting both the greenstone and the diorite. Next in order come a series of dikes of a fine-grained rock which resembles very closely a diorite, and which are found cutting both the granite and the massive diorite. Finally and last of all is a series of gabbro and diabase dikes, the latter of which are probably of triassic age, and are found cutting all the other rocks of the district.

The Greenstone.—This is probably the oldest rock in the area and consequently presents a higher degree of metamorphism than any of the other rocks. The massive phases of this rock are dark in color, medium- to fine-grained, and present phenocrysts of both plagioclase and green hornblende. With this are found tuffaceous phases of the same rock, which, from their general appearance, one would think were laid down by water. These tuffaceous phases of the rock lie to the east of the more massive facies and are in the area which has suffered the greatest dynamic metamorphism. So great, indeed, has been this metamorphism that one may characterize the greater part of the rocks of the greenstone area as greenstone schists. This greenstone is the rock into which the great diorite mass lying to the west was intruded. This is conclusively shown by the nature of the contact of the two rocks. Exposures of the contacts are scarce, being nearly always obscured by the great mass of rock decay, but where they are found the diorite clearly makes a contact against the greenstone. That is, the diorite nearest the contact is very dense, when only slightly removed, clearly porphyritic, and when entirely away from the contact is of medium to coarse in textures and more or less evenly granular. Where contacts cannot be found, the diorite in near proximity to the greenstone shows the phenomena just enumerated to a greater or less extent. Also, dikes of the diorite are found cutting the greenstone. This rock is not widely distributed through the Gold Hill district. A

line drawn from a point near the Peddler's Store nearly south, following closely, but lying to the west of Little Buffalo Creek, would mark its eastern boundary. Extending westward from this line, it occupies an irregular area varying in width from 1 to 3 miles. It is typically exposed in many places in the valley sides and stream beds in the Beaver Hills, especially near Barringer's Mill on Big Buffalo Creek and along the ridge tops southeast of Five Pines.

The Diorite.—This rock comes next in point of age and is, as has just been stated, intrusive into the greenstone. It varies greatly in character, both as to composition and texture. Sometimes it carries more or less quartz and becomes almost a typical "grano-diorite." Again it is found to be practically free from quartz and would be called a typical diorite. The texture varies from finely granular to very coarse. At times the feldspars predominate over the ferro-magnesian constituents of the rock; at others the reverse is true, and again they may be evenly balanced. It seems that there is a tendency on the part of the finer grained variations of this rock to be quartz-bearing. There is, however, no gradation into a granite, the nearest approach being the quartz-bearing diorite. In such an area as this one might expect a magmatic differentiation that would show gradations of the granite and diorite into each other, each being a differentiate from the same magma. This is not true in the case at hand, the granite and diorite wherever they come in contact with each other always having sharp and distinct boundaries. It is believed, however, that there has been more or less differentiation on the part of the diorite magma, and that this accounts for the local variations met with.

Although this rock occupies nearly half the igneous portion of the area, it is by no means well exposed at the surface, the exposures being limited to boulders and to little areas on valley sides and in stream beds. It does not resist weathering very well and is generally deeply buried in its own decay. Probably the best and most typical exposures are those in the vicinity of St. Peter's Church and near Rothrock's Mill on Second Creek. Typical exposures and also variations of the rock type may be seen along the Beatties Ford wagon road near Lower Stone Church and in many places on Jennie Wolf Creek and Black Run.

The Granite.—The youngest of all the igneous rocks, except the dikes, is the granite. This rock is a fairly massive, generally a medium-grained, light-gray granite, sometimes having a slight pinkish tinge of color. There are two distinct phases of this rock, one as described above, a normal gray granite of medium grain; the other is an aplitic facies, very fine grained and carrying only a small amount of ferro-

magnesian minerals. This latter phase is limited in extent and is found in abundance in only one place—on the road leading from Lower Stone Church to Rockwell, about 1 mile north of where the road crosses Second Creek. It is possible that this exposure represents only a large dike, and consequently that this variation of the rock occurs only as dikes. Some strength is given to this hypothesis by the fact that many of the small granite dikes which are found in considerable abundance near the borders of the granite mass cannot be distinguished in a hand specimen from this rock. The main mass of the granite shows some irregularities in texture and varies from a rather coarse-grained rock in the vicinity of Tyack's Store to a medium fine-grained rock exposed in the railroad cuts near Rockwell.

The granite is the youngest rock in the district, and makes a contact against all other rocks with which it is found, except the slate formation lying to the east.

Although the granite occupies a considerable portion of the area, exposures of the rock are by no means plentiful. Probably the best exposure of a fresh granite occurs about 1 mile north of the Peddler's Store, where a small amount of the rock has been quarried for local use. Other exposures of the deeply weathered and sappy rock occur in the vicinity of Tyack's Store and along the Gold Hill-Salisbury road, a short distance northwest of Second Creek.

The Slates.—The rocks here included under the general term "slates" make up the entire eastern half of the area, and while having many local variations, seem clearly to represent a great sedimentary series of shales with which are interbedded volcanic flows, breccias and tuffs. At and near the western boundary of the series, that is, at and near the contact of the igneous rocks to the west, the slates are dipping steeply—about 80 degrees to the northwest. Along this line the rocks are highly schistose and show markedly the effects of intense dynamic metamorphism, and it is in these metamorphic rocks near the contact with the igneous rocks that the important ore deposits occur. As one proceeds toward the southeast the effects of this metamorphism are seen gradually to die out. The dip, while prevailing to the northwest, becomes flatter and even changes sometimes to the southeast and the series becomes more massive and shows clearly its sedimentary origin. In their fresh and massive condition the slates are dense bluish rocks, which have in many places well-defined bedding planes and laminations. The volcanic flows, breccias and tuffs which are interbedded with the slates apparently represent two types of lava—rhyolitic and andesitic. The former occurs in most typical development in Flat

Swamp Mountain, a short distance northwest of Bringle's Ferry, and the latter in the southwest portion of the area, especially in the long ridge which lies to the west of Little Bear Creek.

The slate series tends to form a low-lying, flat country, with low, well-rounded ridges which mark the location of the volcanic beds. The character of the ridges depends directly upon the nature of the material forming them. The rhyolitic flows and breccias of Flat Swamp Mountain form the most prominent topographic relief in the district, and the andesitic flows and breccias near Little Bear Creek are next in importance as ridge-makers. The normal slates form slopes and flat valleys.

These rocks form a very dense, light-colored and exceedingly lean soil, and consequently make the poorest and least valuable lands in the whole district.

Dikes.—Dikes are very numerous in all parts of the district and are of four or five distinct types, which, in order of age, are diorite, granite and quartz-porphyry, fine-grained dense diorite, gabbro and, finally, diabase. The older diorite dikes are not at all numerous, and are found only in the vicinity of Foil's Mill on Buffalo Creek, where they occur in the greenstone. The rock has suffered much alteration, but does not differ essentially from the fine-grained facies of the diorite.

Granite and quartz-porphyry dikes are numerous, especially near the contacts of the granite with the older rocks. They are of two general types—ordinary quartz-porphyry and a very fine-grained aplitic granite. They cut both the greenstone and the diorite, but were not found in the slate area. As a rock, these dikes are of little importance other than from a scientific standpoint. They are generally deeply weathered and their location is determined only as light-colored bands cutting the dark-colored country soil. The second series of diorite-like dikes differ from the massive diorite of the area only in that they are made up of exceedingly fine-grained material and in that they occur cutting the granite dikes and the massive diorite. These dikes have not been able to resist weathering as well as the rocks which they cut, and consequently are recognized only as narrow bluish bands in the decay of the other rocks. One rarely finds even fresh boulders of these dikes, and when found they are small and deeply imbedded in the decay of the dikes.

Next in order come the gabbro and diabase dikes, the former being rare. The diabase dikes are numerous and are found cutting all the other rocks of the district. They are represented on the surface by numerous well-rounded black boulders, known locally as "nigger heads," which are confined to narrow strips that may extend laterally for a considerable distance.

GOLD HILL VICINITY

SHOWING THE LOCATION OF MINES, PROSPECTS AND VEINS

Mines - X
 Prospects - *
 Veins - —
 Quartz Veins - —
 Strike and Dip of Strata - ↗
 Scale - 1:12,000

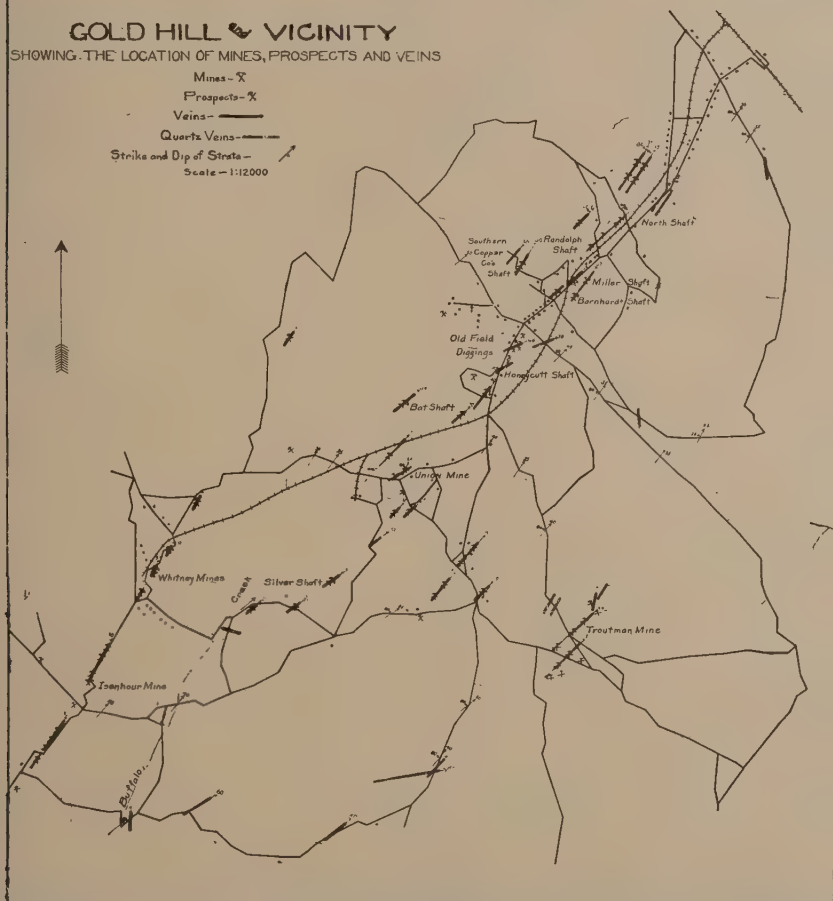


FIG. 2—MAP OF THE GOLD HILL COPPER DISTRICT, SHOWING LOCATION OF COPPER MINES, VEINS AND PROSPECTS.

At times this rock is decidedly porphyritic, the feldspars being large and numerous, forming a rock that may be called "labradorite porphyrite." This porphyritic rock occurs in considerable abundance along the county-line wagon road, about 1 mile northwest of the Whitney Company's mine. It also occurs along the Gold Hill-Salisbury road about $\frac{1}{4}$ mile southeast from the Peddler's Store. It is known locally as "spotted rock." Typical diabase dikes are found cutting all the other rocks of the area and appear to be especially numerous in the mining district, each mine showing up one or more of them. They are probably more numerous in near proximity to the granite-slate contact.

The gabbro dikes are found in both the slate and the diorite formation is limited, but many of them are of large size. In the slates they contemporaneous. Those in the slates are completely saussuritized, while those in the diorite are fresh. Their distribution in each formation is limited, but many of them are of large size. In the slates they are well exposed near Corinth Church. In the diorite they occur near St. Peter's Church and in the vicinity of the Cline Mine. A large gabbro dike is found at the Dutch Creek mines.

In trend all the dikes are dependent upon the structure of the region and invariably follow one or other of the numerous joint systems.

Structure.—The structure of the Gold Hill district, broadly speaking, is simple. It consists of a series of slates interleaved with which are bands of rather acid andesitic tuffs and small flows of the andesite and rhyolite, this series being separated by a fault of undetermined throw from the igneous rocks which make up the northwestern portion of the district. The slate area presents no important or complex structural phenomena. The formation has been jointed and thrown into minor folds with a prevailing northwest dip which varies from horizontal to almost vertical in the immediate locality of the Gold Hill fault zone. In this fault zone the rocks have been to a considerable extent altered into schists. Jointing and minor folding are well shown, but, with the exception of the one great fault and the zone of minor faulting at and near to the contact with the plutonic rocks to the northwest, there is nothing of much structural importance. The greenstone, diorite and granite areas present only the usual phenomena of such rocks. All the igneous rocks are closely jointed and the older formations show more clearly the effects of metamorphism than the younger rocks.

Folding.—The slate series within the district, with the exception of the portion in the immediate vicinity of the western contact, has suffered comparatively little dynamic metamorphism. The series as a whole has been thrown into large folds upon which have been imposed many minor folds, and with the development of which there have been

connected more or less faulting and more buckling in the immediate proximity to the main fault lines. Near the faults the strata are vertical and show markedly the effects of pressure metamorphism. Between these areas the strata are thrown into minor folds with no steep dips, oftentimes being approximately horizontal. Thus it appears that instead of the slate series yielding as a whole and being thrown into a few broad folds, it yielded by fracture in certain places and by buckling in the intervening areas. It may be, however, that the series has yielded as a unit, having been thrown into a large anticlinorium upon which are imposed the faulting and the minor folding mentioned. Only a small portion of the whole slate formation is included within the limits of the map here presented; indeed, so small a portion that no general conclusions applicable to the series as a whole can be drawn. The two theories, therefore, are stated only as possibilities. Evidences from sources outside the area mapped seem to favor the latter view.

The portion of the slate series within the map shows these rocks dipping very steeply toward the northwest at and near the granite greenstone contact. This northwest dip continues for a distance of from 2 to 3 miles to the southeast, where a minor fold reverses the dip for a short distance. It, however, assumes its normal northwest dip and is dipping in this direction at varying degrees—20 to 60 on the extreme eastern limits of the map. The strike of the folding is nearly always to the northeast and varies from 15 to 60 degrees, averaging about 35 degrees.

Jointing.—One of the most noticeable features of the whole Piedmont Plateau is the great number of joints. These joints, while well distributed throughout the whole 360 degrees of the circle, show a decided preference for certain directions and are found, as it were, grouped around three main directions.

Out of a total of 141 measurements of joints scattered throughout the whole Piedmont region, it was found that they could be grouped roughly as follows:

Total number of joints with strike	N. 10°—80° E.	61
	N. 10°—70° W.	52
	N. — S.	18
	E. — W.	10

Similar measurements of the trend of basic dikes in the same region gave the following group:

Total number of dikes with strike	N. 10°—50° W.	20
	N. 20°—40° E.	21
	N. — S.	6
	E. — W.	1

Thus, while there is a slight majority of the joints with a northeast strike, the dikes are about equally divided between the northeast and the northwest quadrants. East and west, and north and south trending joints and dikes are rare. In the above observations no attention was given to the dip of the joint planes.

Close attention was given to jointing in the Gold Hill district, both as to trend and dip of the joint planes. The results are in every way similar to those in other portions of the Piedmont Plateau.

In the slate formation there are not so many joints with the northeast trend as in other portions of the district, the reason for this being, perhaps, the ability of the joint-producing force to relieve itself along the northeast trending planes of parting in the slates.

Faulting.—Numerous insignificant dislocations are met with in nearly all portions of the district in which any prospecting has been done. These never, as far as noted, amount to more than a few feet, and are probably only the minor adjustments due to the faulting of the region, and are therefore of no great importance. In the mine workings, especially those of the Union Mine, there are a few offsets in the vein due to faulting; but from as close observation as it was possible to make upon these specific instances, it is believed that, while the fractures are true faults, they occurred prior to the mineralization.

There is believed to be one fault of considerable magnitude in the district, and this, together with the system of minor faults developed contemporaneously, has not only an important effect upon the ore deposits but also a most important bearing upon the principal relations of the different formations to each other and upon the physiography of the district. This is the Gold Hill fault which marks the western contact of the slate formation. It is only after a very close and detailed study of this contact, and after every other theory to account for conditions as they exist had failed, that the fault is admitted.

This fault zone extends through the entire district, with an approximate trend of N. 15° E., entering from the southwest near the confluence of the two Buffalo creeks and passing out about $\frac{1}{4}$ mile northwest from the mouth of Second Creek. A straight line drawn between these two points would approximately mark the contact of the slate formation on the east with the greenstone and the granite on the west. This line would very nearly mark the courses of Little Buffalo Creek flowing southwest, and Reedy Branch flowing northeast. (Fig. 3.) Both streams lie a short distance to the east of the line of contact, but flow approximately parallel with it. In no place was the actual contact between the formations visible, everything at and in the near proximity of this fault

line being deeply covered with the residual rock decay. Hence, it is only upon secondary evidence that the existence of this fault is deduced. These will now be stated and discussed.

1. The relation of the slate to the granite and the greenstone.

2. The absence of metamorphism in the slate series at the granite contact, and also the absence of a contact zone in the granite against the slates.

3. The absence of granite and aplitic dikes near and at the contact like those found in the diorite and greenstone near their contacts with the granite. Not a single dike of such description was found, although a very close examination of the territory near the contact was made.

4. Actual faults in the mines with strike apparently parallel with this main fault line, these lines of faulting clearly cutting the schistosity of the slates.

5. The very prominently developed system of joints with the trend approximately parallel with this assumed fault line, many of which have slickensided surfaces.

6. The fact that within the district the streams in the territory near this line follow it and not the schistosity as they do farther away from this line. If there had been faulting attended by the formation of a zone of brecciation, this zone must necessarily be more easily eroded than the unbroken slates. The streams would consequently find favorable ground along this line in which to work. In the territory more remote from this line the stream courses are controlled by the hard and soft layers in the slates, and conform to the strike of the schistosity. Reedy Branch and Little Buffalo Creek, which follow this line of contact, flow across the schistosity at a very acute angle and entirely regardless of hard and soft beds, making only slight curves around the more resistant portions, but no bends of any importance.

7. The relation of the streams to this line when it is produced beyond the district in both directions. The sketch map (Fig. 3) is taken from a map of North Carolina published in 1892 by the North Carolina Geological Survey. An examination of this map will show that there have probably been some exceptional causes for the approximately straight line of Abbott's Creek, Reedy Branch, the two Buffalo creeks and Rocky River. These stream courses form a line at least 75 miles in length, and this line is seen to be simply an extension of the line of contact between the slates of the granite and greenstone. It seems strange that Abbott's Creek should have a course cutting the schistosity of the slates at an acute angle when the other streams follow it, unless there had been some exceptional cause, something that would afford easier ground in which to work. From a hasty examination of the

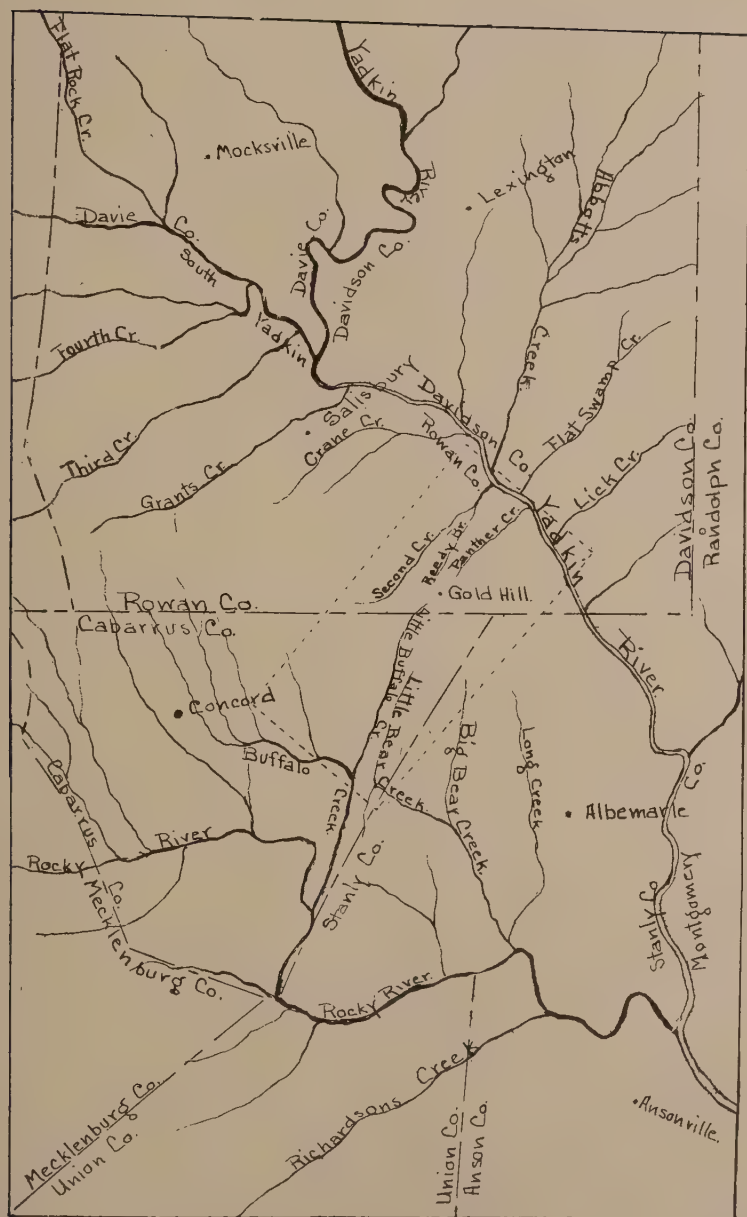


FIG. 3.—MAP OF THE YADKIN AND ROCKY RIVERS, AND THEIR TRIBUTARIES.

country contiguous to Abbott's Creek, no such reason, unless it be faulting, is believed to exist. It also appears as if some similar cause may be responsible for the peculiar form of Buffalo Creek and Rocky River. It seems possible that these streams may represent cases of stream capture, that possibly at one time Buffalo Creek reached Rocky River through the channel now occupied by Bear Creek and at this time made its way to the Yadkin by a roughly parallel course now followed by the small stream south of Bear Creek and just east of the elbow in Rocky River. Given these streams in this relation and a smaller tributary working headward along the soft and easily eroded material that would be produced in a fault zone, and the phenomena now presented upon the map would be the normal result.

8. The line of contact throughout its entire length is marked by numerous springs, while the region remote from it is not well supplied with them, nor is the granite diorite contact marked by such an abundance of springs.

9. The continuous mineralization along and near this line of contact and its extension is regarded as having some weight in favor of the assumption of such a fault. By reference to the sketch-map it will be seen that the greater part of the mines in this part of the State lie close to the line formed by the extension of this line of contact. The majority of the ore deposits of these mines are described as fissure veins, either of mineralized quartz or as stringers of ore in fractured or splintered slate, and they furthermore are described as having a strike somewhat east of north. This is known to be the case with the group of mines at Gold Hill. It is not understood how a mere local cause could result in the formation of fissures along the line something like 50 miles in length; neither is it understood how such extensive mineralization could have taken place along a line of such great length simply as the result of local causes.

It is realized that the facts above presented do not prove conclusively that such a fault zone exists, but the evidence is believed to be strong enough to warrant such an assumption. Hence, it is believed that such a fault zone does mark the contact between the slate series and the igneous rocks lying to the northwest. It is not possible to say definitely which is the downthrow and which is the upthrow side of this fault. From observations as to hade of the fault planes in the minor parallel faults in the mines and the appearance of the slickensided walls in such faults, it is believed that the northwest side represents the upthrow.

THE ORES AND MINES OF THE GOLD HILL DISTRICT.

Historical.—The earliest mining within the Gold Hill district was for gold, but as the mine workings increased in depth the sulphide ores were reached, and these were found to carry copper as well as gold. These two metals, with which occur a little silver, are the objects sought for by the miners of the present day.

Gold was first discovered within this district at the Barringer Mine prior to 1824,* but the country lying to the southwest and southeast had been the seat of gold mining since the beginning of the century. This mining took its beginning at the Reed Mine, which lies only a few miles from the southwest limit of the area shown on the map. The first authenticated discovery† of gold in North Carolina occurred at this mine in 1799, when a nugget weighing $3\frac{1}{2}$ pounds avoirdupois was picked up in the bed of Meadow Creek on the plantation of Joel Reed. Further search resulted in finding a number of large nuggets, the largest of which weighed 28 pounds avoirdupois. The whole number of large nuggets discovered at this mine between the above date and 1834 was 14 and represented a weight of $115\frac{1}{2}$ pounds avoirdupois.

With the discoveries at the Reed Mine, active prospecting began and spread throughout the whole surrounding country, confined for the most part to the "slate area," which was found to be the most promising. Indeed, at a very early date in the century the slate formation was known as the "gold country." Denison Olmstead,‡ writing in 1824, says: "They [the gold mines] are situated in the southern part of the State, not far from the borders of South Carolina and somewhat west of the center. Through the 'Gold Country' flows the river Pedee [Yad-kin], receiving within the same district two considerable streams, namely, Rocky River from the south and Uwahree River from the north * * The 'Gold Country' is spread over a space of not less than 1,000 miles * * * From a point taken 8 miles west by south of the Uwahree, with a radius of 18 miles, describe a circle—it will include most of the county of Montgomery, the northern part of Anson, the northeastern corner of Mecklenburg, Cabarrus as far as a little west of Concord, and the corners of Rowan, Davidson and Randolph * * * In almost any part of this region gold in greater or less abundance may be found at or near the surface of the ground." The area just described includes all the Gold Hill district. The principal gold-bearing veins, those at Gold Hill, were not discovered until 1842. Outcroppings of these veins were not prominent, and it is said that they were discovered by accident.

*A Report on the Geology of North Carolina. Denison Olmstead, p. 84, Raleigh, 1824.

†Historical Sketches of North Carolina from 1584 to 1851. John Hill Wheeler, New York, 1851. Vol. 2, p. 64.

‡A Report on the Geology of North Carolina. Denison Olmstead, p. 33, Raleigh, 1824.

Between the date of discovery and the beginning of the Civil War, mining was carried on at Gold Hill with considerable profit, and the place became widely known as a mining center, producing in this time, it is said, something like three million dollars.

At the beginning of the Civil War, the main shaft, the Randolph, was down to a depth of 700 feet, and the richer portions of the vein for about 1,500 feet were worked out to a depth of about 350 feet. The upper or oxidized portions of the vein were found to be very rich and the gold was easily extracted, amalgamating, it is said, very easily. The methods used in concentration were crude. The ore was first ground in an *arasta*, a kind of Chilian mill, made of two large granite "runners" and a large granite "bed." The mill was operated by horse power. The ore, after being run through this mill, was washed through a system of wooden rockers.

During this period of active mining quite a number of smaller mines and prospects were opened up at considerable profit. Among these are the McMackin (now known as the Whitney Mines), the Troutman, the Barnhardt, the Honeycutt, and the Old Field mines. The McMackin, the Troutman and the Honeycutt mines are said to have paid well until the upper portions of the veins were worked out. In these cases, as at the Gold Hill Mines, the operators were unable to handle the ores satisfactorily when the depth of mining increased and the unaltered sulphides began to come in. Their methods of concentration were too crude for ores that did not amalgamate easily. The copper of the sulphide ores, of course, could not be saved by such processes, and in general no attention was paid to it.

Until the discovery of the gold-bearing vein in *situ* at the Barringer Mine about 1824, all the gold mined was obtained from small placer workings in the stream beds and valleys. The methods of work were most primitive, sluice boxes and log rockers. With the discovery of the gold-bearing veins came the introduction of the Chilian mills, or gold grinders, as they were called, and these were still in use when the Civil War caused a cessation of all mining.

The mines were not opened up again until some years after the close of the Civil War. When the work was resumed, better and more extensive machinery was installed, and attempts were made to save both gold and copper, but with indifferent success. It seems that the operators, very soon after the reopening of the mines, began to use them as speculating properties, and while considerable legitimate and *bona fide* mining was carried on, it seems that the principal object was one of stock manipulation.

Geology of the Mines and Prospects.—Four mines and numerous prospects called mines represent the workings in the Gold Hill district. They are for the most part confined to the western edge of the slate formation and apparently to the immediate zone of the Gold Hill fault. The important openings, the Gold Hill Mine, owned by the Gold Hill Copper Company; the Union Mine, owned by the Union Copper Company; the Whitney Mines, owned by the Whitney Reduction Company, and the Southern Copper and Gold Mining Company's openings, together with numerous diggings and prospects, make up the Gold Hill mines. Of these the first two and the last one are located upon the Gold Hill Ridge, the Gold Hill Mine in the village of Gold Hill, the Union about $\frac{3}{4}$ of a mile southwest of the village, and the Southern Copper and Gold Company's shaft, located a few hundred yards west of the Randolph shaft. The Whitney Mines lie to the west of Buffalo Creek and, while not in the Gold Hill Ridge, are in the same fault zone and on the same side of the main fault line. Of these, the Gold Hill Mine, the Union Mine and the Southern Copper and Gold Mining Company's mines were in operation in 1907. (See Fig. 2.)

If a line be drawn through the Gold Hill and Whitney mines and produced to the southwest limits of the district, it will run roughly parallel with the Gold Hill fault line, crossing it just west of St. Steven's Church, where it passes into the greenstone. This line will be marked throughout its length by more or less prospecting and other evidences of mineralization. The principal prospects that have been opened in this portion of the district, the greenstone area, are the Klutzz, Harkey and Hopkins diggings.

Lying about $1\frac{3}{4}$ miles northwest of the Hopkins Mine is another group of prospects known as the Cline Mine and the Dan Hopkins diggings. The last of these is located in the diorite and the former in the greenstone very near the diorite contact.

The fourth and last group of prospects of the district is located near Garfield Post Office (Tyack's Store) and consists of two groups, one in the granite to the east of Second Creek, and the other to the west of the creek and in the diorite very near the granite contact. These are known as the Dutch Creek and the Gold Knob mines, respectively.

Types of Deposits.—These four groups of mines and prospects represent four classes or types of deposits. They may for convenience of description be designated as follows:

1. The Gold Hill types. In this the ores consist of auriferous pyrite and chalcopyrite in a more or less quartzose gangue, or as narrow stringers in rifts in the schists with little or no gangue material. The Gold Hill Mine and the Union are good examples of this type.

2. The Greenstone type. In this type of deposit the ores consist of slightly auriferous bornite and chalcocite in a gangue of quartz and epidote, very little or no chalcopyrite being present. This is exactly similar to the ores of the Virgilina district which Mr. W. H. Weed* has described as the Virgilina Type of southern copper deposits.

3. The Cline type. In this the ores consist of auriferous pyrite and chalcopyrite in a well formed quartz vein with a gangue of quartz, hematite, siderite and calcite. The Cline Mine and the Dan Hopkins diggings are the examples of this type. This type of vein and gangue minerals are very characteristic of the old Conrad Hill Mine†, which is located northeast of the Yadkin River in Davidson County, on the continuation of the Gold Hill fault line.

4. The Dutch Creek type. In this type the ores consist of auriferous pyrite and a small amount of chalcopyrite in a quartz gangue, the vein being located in the granite. The Dutch Creek Mines are examples of this type.

The Gold Hill type. This type of deposit includes two classes of veins, one consisting of stringers of ore filling narrow spaces between thin layers of the schist and presenting little or no evidence of silicification; in the other class the veins are larger, are highly silicified and show that more or less silicification of the country rock has taken place. The former are largely copper-bearing, the ore for the most part consisting of chalcopyrite in a gangue of pyrite, and carries very little gold. The latter carries, as a rule, only a small amount of chalcopyrite and is largely made up of auriferous pyrite in a more or less quartzose gangue. There are exceptions to these statements, but, in general, ores that carry high values in gold carry only a small amount of copper, while those high in copper are very low in gold. Both classes of veins have been developed along fractures in the country rock which may or may not run parallel with the schistosity. There is, however, as a rule, a general conformity between the strike of the veins and that of the country rock.

The schists at the mines have a strike varying from N. 30° E. to N. 45° E. and dip about 80° to the northwest. The outcrops of the veins are obscure and it is next to impossible to trace them upon the surface. The usual outcrop consists of only a narrow band in the schists which stands up a little more prominently than the surrounding rock, and which generally shows a more decided staining due to

*Types of Copper Deposits in the Southern United States. W. H. Weed, Trans. Am. Inst., Min. Eng., Vol. 30 (1900); 449-504.

†Metallic Wealth of the United States. J. D. Whitney, p. 130. Geology of the Midland Counties of North Carolina. Ebenezer Emmons, pp. 143-154.

the oxidation of the iron. Where the vein is quartz, this mineral marks the trend of the vein by its fragments. The largest and richest veins, however, are not quartz veins, being only more or less highly silicified bands or stringers in the schists.

The first type of vein varies greatly in degree of silicification at times, and even the walls are so highly silicified that they resemble chert and the ores are distributed irregularly through this highly silicious ground mass. At other times there is only a relatively small degree of silicification and the rock walls have suffered little or no alteration. This type of vein usually has well defined walls which frequently present slickensided surfaces.

The second type of vein consists to a great extent of a number of narrow stringers or bands of ore filling closely spaced openings or rifts in the country rock parallel with its schistosity, and presents a minimum amount of silicification.

True quartz veins in the vicinity of Gold Hill are not numerous, and are always narrow and lean or wholly barren. All the veins in a general way follow the dip and strike of the schistosity, but do not follow either continuously and are seen to follow one plane of foliation for a short distance and then break across to another. On studying a plan and elevation of this formation it is seen that the trend of the vein as a whole is not quite so strongly to the east as that of the schists, and that they really do cut the schists at low angles. The vertical sketch shows that the veins may have a steeper vertical dip than the schists, though at times the offset occurs in the other direction, thus giving the vein a flatter dip than the schists. An excellent example of this relation of the vein to the country rock is seen in the north vein of the 800-foot level of the Gold Hill Mine, which vein was being worked in 1907. A sketch, made from an actual survey of this level of the mine, showed very well the great number of small veins or stringers of ore, not less than eight in number, associated with three workable veins within a distance of 800 feet. The smaller veins, while sometimes high in values in either gold or copper, are always too small to work. They present the same features as regards vein matter and ores, and have the same relations to the country rock as do the larger veins. That is, they may follow either the schistosity or one of the numerous lines of fracture, or both schistosity and fracture, crossing from one plane of schistosity to another, following the line of fracture leading across them.

That the veins follow fractures in the schists is evident from the nature of the vein contents, their relations to the country rock and the very prominent slickensides which are developed upon the wall rock in

many places. The veins in many instances are seen to contain numerous angular fragments of hard silicified rock not unlike many of the bands of dense schist. That is, they show evidences of more or less brecciation. In other instances, the vein instead of being a breccia is made up of numerous stringers of ore filling narrow spaces between shreds of the schist, appearing as though the schists had been torn apart, and suggesting somewhat a fracture in a piece of tough wood in which the main fracture consists of many small fractures with splinters extending between them from wall to wall. Sometimes these breccias and stringers show that considerable replacement has taken place since their formation, they being more or less replaced by quartz and ore. In other instances they are approximately fresh.

The veins as well as the ore shoots within them have a well defined lenticular structure, sometimes attaining a width of from 5 to 15 feet and again gradually narrowing down to a width of only a few inches, or even pinching out entirely, leaving only slickensided walls in contact with each other. This lenticular structure is prominent in both longitudinal and vertical sketches of the vein. If the figure showing the relation of the vein to the country rock be examined, it will readily be seen how even a slight movement of either wall in any direction must necessarily tend to produce just such lenticular spaces as have been described. In addition to their lenticular character, the veins also possess other irregularities. Stringers of ore may lead off from the main vein and follow the planes of schistosity, and at times they are seen to follow one of the numerous joint systems.

It also appears probable that there has been very little fracture with appreciable dislocation since the deposition of the ores. It is true that in some instances the miners report slight dislocations in the veins, but it seems probable from observation in a few such instances in the Union Mine that such dislocations are for the most part due to an offset in the original fault line prior to the formation of the vein. It is also true that many joints and, in a few instances, diabase dikes are found cutting the veins. Every instance of a diabase dike in this relation in both the Union and Gold Hill mines was examined in detail, and in no case was there found any appreciable dislocation in the vein at the dikes. The vein in every instance in which the dike had been cut through was found to resume its regular trend on the other side of the dike. These dikes often run parallel with the veins, sometimes following one or the other wall for greater or less distance. In one instance, in the Barnhardt Mine, a dike was encountered which came up to the vein on one side, followed it for about 20 feet and then crossed it at nearly right angles and appeared in the other wall.

THE ORES.

The ores of the Gold Hill district are auriferous pyrite and chalcopyrite, with which is more or less gold-bearing quartz, quartz being the only gangue mineral of any importance. The gold values run higher in proportion as the copper values decrease; that is, the gold seems to occur with the pyrite to a greater extent than with the chalcopyrite. From detailed examinations of the respective "gold veins" and "copper veins" of the Gold Hill and Union mines, it seems probable that the copper and gold infiltrations are of two separate and, to a certain extent, distinct periods of mineralization, the one furnishing the copper with a small amount of gold and the other supplying the gold with a small percentage of copper, both of these being younger in age than the pyrite. It is believed by the operators that the "gold veins" are more highly quartzose than the "copper veins." With the pyrite and chalcopyrite also occur small amounts of sphalerite and galena, but in such small quantities that they are of no value. There is, however, one exception to this statement, the "silver shaft" of the Union Copper Company, which has produced considerable silver from an argentiferous galena.

The relation of Ores and Gangue.—The ores all contain more or less gold which will amalgamate readily, but there is also always a high value remaining in the concentrates, values representing from one-fourth to one-third the assay value of the ore. The gold in the quartz is known to be in free condition, as is also a part of the gold in the sulphides. Because of the high value of the concentrates, it has been assumed that at least a portion of the gold was present in chemical combination with the sulphur, or isomorphous with the iron and the sulphur. With the hope of determining the condition of the gold in the sulphides and also the relation of the sulphides to each other, a large number of specimens of typical sulphide ores rich in gold were selected for microscopic study.

Relation of the Sulphides.—The sulphides present in the sketches examined are pyrite, chalcopyrite, galena, sphalerite, bornite and chalcocite, the bornite and chalcocite not occurring with the other sulphides. The principal object sought by this study was the relation of the pyrite to the chalcopyrite, the ore being the so-called cupriferous pyrite, the especial object being to determine whether or not the ore consisted of a mechanical mixture of the two minerals, or whether it was really a copper-bearing pyrite. In every instance in which these two minerals occurred together it was evident that the ore consisted of a mechanical mixture of the pyrite and the chalcopyrite, each mineral

having its own definite boundary lines against the other, the pyrite being the older of the two. The order of deposition seems to have been first the pyrite and then a shattering of this mineral, followed by the introduction of the chalcopyrite, which is seen surrounding and filling in the spaces between the fragments of the pyrite crystals, often running out into knife-edged pieces in the minute cracks in the pyrite, the appearance being that of a breccia in which the fragments of pyrite were formerly imbedded in a matrix of chalcopyrite. Each mineral always had its own boundary lines clear-cut and sharp, there being absolutely no gradation of one into the other. Some of the pieces of chalcopyrite seem to have the form of pieces of pyrite, and it is possible that these may represent a replacement of the pyrite by chalcopyrite. Quartz was also present in the sections, but its definite relative age could not be determined. In part it appeared to be contemporaneous with the pyrite and in part contemporaneous with and later than the chalcopyrite.

When galena and sphalerite occurred, both seemed to be subsequent to the other sulphides, and of these two the sphalerite is subsequent to the galena. These minerals were only sparingly present in the sections examined.

Only a few sections of the bornite and chalcocite were examined. In every section of this ore examined the surface was seen to consist of a mass of bornite clearly distinguished by its peculiar bronze color through which was running a mesh or network of bright glistening lines of chalcocite, the amount of the respective minerals varying greatly. If the section appeared to be largely chalcocite, the lines of the network of this mineral were broader and many irregular areas of it occurred. If, on the other hand, the bornite were present in greater amount, the lines of the network of chalcocite were narrower and fewer in number, and there were only a few of the irregular areas just mentioned. The bornite did not as a rule present very clear-cut boundary lines against the chalcocite. No very positive statements can be made as to the relative age of the two minerals, but the appearance of each mineral and their relations to each other seem to suggest that the chalcocite may be secondary to and derived from the bornite.

RELATION OF GOLD TO SULPHIDES.

One of the principal objects of the microscopic examination of the ores was to determine, if possible, the condition of the gold in the sulphides. Many of the sections were from lean ore and no gold could be seen in them, even when careful panning would show its presence;

but in the majority of the sections, especially of the richer ores, it was not difficult to detect. The ores used in making the sections showed assay values running from \$5 to as high as \$375 per ton.

In every section in which gold could be distinguished in the sulphides (it occurred in the quartz also, but little attention was given to this), it had its own distinct and clear-cut boundaries and was clearly subsequent to the sulphide in which it occurred. Its manner of occurrence was not essentially different from that of the chalcopyrite in the pyrite. It was seen filling irregular areas and cracks in the pyrite, frequently running out to the very extremity of a narrow knife-edged crack, at times filling two or more roughly parallel cracks with stringers running from one to the other, and often filling the most irregular areas in the pyrite. It was in no case distributed evenly through the sulphide, but seemed to be more or less concentrated in certain areas. In only a few doubtful instances was it seen in the chalcopyrite, but there was no difficulty in finding it in the pyrite. The pyrite in all the sections was examined with great care to ascertain if it presented any peculiarities of structure, form or color that might indicate a chemical union with the gold, but, with only one or two doubtful exceptions, were any such features detected. These appeared to consist of striped areas in the midst of a fair-sized grain of pyrite which had a slightly different luster and color from the other portions of the grain. These areas were always small and had irregular boundaries. Their nature could not be determined. While it is possible that they may represent some kind of a combination of gold with the sulphide, it is believed that they are due to irregularities resulting from grinding and polishing the section, or possibly due to tarnish.

When the gold occurred in connection with galena in the pyrite, there was always difficulty in determining the relative age of the gold and the galena; sometimes the evidence seemed to favor the idea that the galena was subsequent, while again the reverse seemed to be the case. The gold in such occurrences always had clear-cut and well-defined boundaries against the galena. From the few instances in which the two were seen in juxtaposition it is not possible to make any definite statement as to the relative ages. It is believed, however, that the galena is subsequent to the gold.

As to the condition of all the gold in the sulphides, the work thus far done will not warrant any definite statements, but it is believed that it occurs only as free gold and not in a chemical combination with the sulphide or as a sulphide itself. This statement seems to be favored by the fact that in every instance in which the metal was detected in the sulphide it was in the native condition, and also by the fact that the pyrite in which it occurred always had, with only doubtful excep-

tions, its usual physical characteristics. The fact that all the gold will not amalgamate may be urged against the above conclusion, and this has been given due consideration. There is one very strong reason why the values cannot all be extracted by amalgamation. This is the fact, well shown under the microscope, that the gold runs out into such minute cracks in the pyrite that it would be impossible to crush the ore finely enough for all the gold to come in contact with the mercury without sliming the whole mass. Microscopic examination of the gold panned out from the ores examined adds weight to this statement in that it shows the gold to occur in exceedingly thin scales and very small irregular particles. There is also opposed to the possible combination with the sulphides the well-known fact that iron or ferrous salts will immediately precipitate gold from its solutions.* It therefore seems that the evidence is strongly in favor of the belief that all the gold in the sulphides is present in its native form.

NATURE OF THE ORE BODIES.

It has been stated that the veins have a lenticular structure, as seen in both horizontal and vertical plan. All portions of the vein are not of equal richness, although throughout the entire lengths of the exposed veins there is more or less mineralization; but it is only in certain portions that the mineralization has been of sufficient magnitude to form workable ore bodies. These ore shoots, of course, lie within, or rather are simply the richer portions of the vein. They, however, present irregular outlines and have a decided pitch to the southwest. In extent they vary longitudinally from 20 to over 100 feet; vertically from 100 feet to the greatest depths of the mines, about 800 feet. The values are not uniform throughout these distances, and the shoot shows all the "pinches" and "swells" of the vein. Ore shoots are best shown up in the Gold Hill Mine, the workings of which seem to indicate three and possibly four shoots.

In the detailed examination of the ore shoots in this mine it was interesting to find that the slickensides on the walls of the veins were not vertical, but were inclined to the southwest at an angle approximating the pitch of the ore shoots. This and the shape and pitch of the ore shoots seem to indicate that the dislocation along the lines of faulting now marked by the vein had both a vertical and longitudinal component. The slickensides in the 300-foot level of the Barnhardt shaft showed a similar inclination, but the workings have not been extensive enough to indicate anything very definite as to the pitch of the ore shoots, two of which have been worked to a limited extent.

*A treatise on Metamorphism. C. R. Van Hise, Monograph 47, U. S. Geological Survey, p. 1091, et seq.

Relation of Ore and Gangue.—As has been stated above, there are two types of veins: one in which the ores occur as stringers in the schist, the other in which they occur with more or less quartz as gangue. In the first type the vein consists of numerous narrow stringers of ore which lie in the opened-up planes of schistosity of the rock and which are separated one from another by narrow bands of the schist. There is no gangue in such a vein, the ore occurring simply as a filling in the rifts in the slates, and the vein consisting of a group of these stringers of ore and schist. In this type of vein there has been little or no silicification of the immediate schists, and only a very limited deposition of quartz. The diagram (Fig. 4) is an attempt to illustrate this type of vein structure.

The other and prevalent type of vein differs from that described above in being more highly silicious, containing numerous mashed and drawn-out fragments of the country rock, and also much more white quartz. This vein is apt to be larger and more persistent than the other type, and it shows to a greater extent the evidence of the schists having been replaced by quartz, thus indicating possibly a more vigorous circulation. In this type of vein the ores may have a banding parallel with the schistosity of the rocks, the bands often spreading out and including elongated areas of the silicified schists, the ore following around these and other smaller fragments in graceful curves. In some instances it seems evident that areas of the broken schist have been replaced by the ore. In the more highly quartzose portions of these veins the ore has an irregular distribution through bluish gray, quartzose ground mass. These ores usually carry their values in gold rather than in copper, while those of the first type have their values in copper, with only a small amount of gold. In each type the pyrite seems to have been the first sulphide to be deposited. Subsequently there came in, in one instance, considerable quantities of chalcopyrite which formed a kind of cement, as it were, filling the fractures and cracks in and around the pyrite. In the other there seems to have been very little chalcopyrite, but considerable gold, which was deposited in the manner described. The solutions which deposited the gold, especially in the Gold Hill Mine, seems to have been more highly charged with silica, and to have had a much more marked effect upon the materials of the vein. The veins rich in gold in this mine seem to be more highly silicious than those which carry copper and only a little gold.

MINES AND PROSPECTS OF THE GOLD HILL TYPE.

As typical examples of this type of deposit, the following may be mentioned: Mines and prospects belonging to the Gold Hill Copper Company, the mines and prospects belonging to the Union Copper

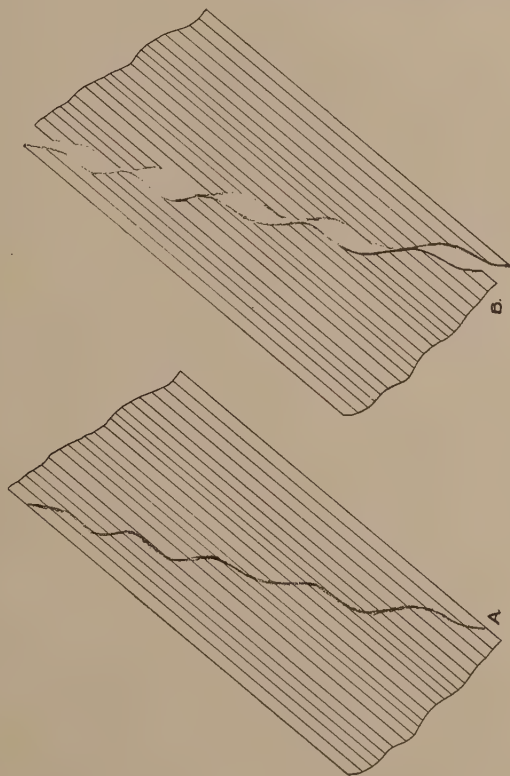


FIG. 4--DIAGRAM ILLUSTRATING OCCURRENCE OF COPPER VEINS IN SCHISTS, AT GOLD HILL. THE SCHISTS HAVE OFTEN BEEN DISTURBED, SO THAT THE RIFTS NOW HAVE THE APPEARANCE AS SHOWN IN B.

Company, the mines and prospects belonging to the Whitney Company, and those of the Southern Copper and Gold Mining Company. They will now be described somewhat in detail. (See Figs. 1 and 2.)

The mines and prospects of the Gold Hill Copper Company.—These consist of the Gold Hill Mine (Randolph shaft), the Miller and Barnhardt shafts and the Old Field diggings.

The Randolph is one of the deepest shafts in the South, reaching a depth of 820 feet, and the workings from it and from a line of caved and dilapidated shafts on the same vein immediately to the northeast have been more extensively stoped than any other mine in the State. From these shafts the workable ores of the largest vein in the mine (the Randolph), varying in width from 2 to 15 feet, have been removed from about 1,500 feet of the linear length of the vein to a depth of about 700 feet. In addition to this work there have been numerous exploratory drifts driven into the walls, thus showing both the location and pitch of the ore shoots, and, to a certain extent, the character of the wall rock. The ore shoots have been discussed in another place (p. 36) and will not be taken up here any further than to state that the ore in the upper levels—in the oxidized zone—was an exceedingly rich free-milling gold ore, and as depth increased the sulphides began to come in and the gold values greatly decreased. No records of the early workings were kept, and the depth of oxidation, etc., cannot be given. It appears, nevertheless, that the first sulphides encountered were fairly rich in gold and carried a low percentage of copper, from 2 per cent. to 10 per cent. Both values seemed to have decreased with depth as well as the width and extent of the ore shoot. At the present depth, 800 feet, the assays from this vein show from a trace to \$2 per ton in gold and from 1 per cent. to 3 per cent. of copper, the vein being narrow and unpromising.

The greatest amount of exploratory work has been done on the 800-foot level, about 2,000 feet of drifts having been driven both along the trend of the veins of the upper levels and across the schistosity of the country rock. This work has been mentioned and discussed to a limited extent in another place and also a sketch of the workings made from a recent survey, but it may be well to discuss it in greater detail at this point.

The drifting started at the shaft and was driven in two directions, approximately at right angles, to the schistosity of the country rock, to a distance of 440 feet to the south and 360 feet to the north, intersecting no less than eleven mineralized bands of greater or less importance. Three of these were of considerable size and drifts were driven along them for some distance. These three are the Randolph vein, which was

very rich in the upper levels of the mine; the Miller vein, which had been opened up by the Miller shaft in one place to a depth of 160 feet and by the Barnhardt shaft in another to a depth of 435 feet, and the new North vein, which was not known to exist prior to this work.

The small stringers are of no importance from an economic standpoint, but of interest in that they show that the Gold Hill ridge at this point is made up of a zone of mineralization, and that this has taken place in fractures and openings formed by faulting. The fact that some of these veins "run" with the strike of the schistosity, while others cross it at acute angles, shows that there was cross-fracturing as well as fracturing along the places of schistosity, which is believed to have been developed long before the faulting occurred.

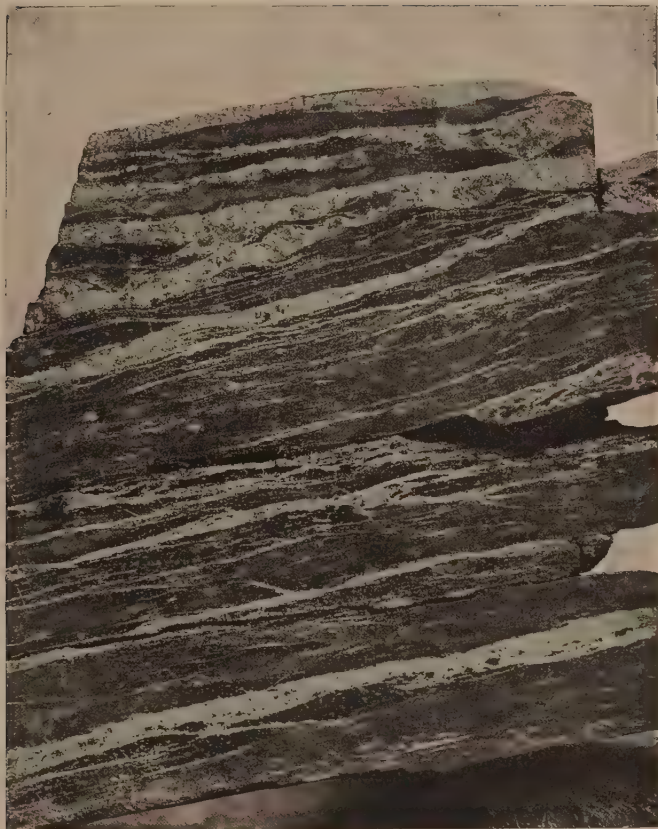
The work along the strike of the Randolph vein showed conclusively that the rich ore shoot of the upper workings did not extend to this depth. It also showed that the fracture along which the mineralization took place not only extended to this depth, but was mineralized, not, however, to the same extent as in the upper levels. Furthermore, it revealed a series of fault planes trending N. 30° W. which presented more or less brecciation, but no displacement of any moment.

The vein encountered at a distance of 440 feet south from the foot of the shaft is in all probability the same vein opened up by the Miller and Barnhardt shafts.

This vein has been exposed along its trend for a distance of about 150 feet. In character it is not essentially different from the vein in the Miller shaft and drifts, and in all probability is the same vein. Where it was first encountered, and still in the northeast end of the drift, it is narrow, but as work was continued westward along its trend, it was found to gradually increase in width until in the present south-west heading of the drift the vein has a width of about 12 feet. (By the word vein is meant that portion of the schists with which the ore is interleaved, and not that the body of ore is 12 feet in width. If all the ore now showing in the heading of the drift were concentrated into a single vein of solid ore, it would not have a width of more than 12 or 15 inches.) This amount of ore is simply interleaved with about 12 feet of rifted schist in the manner shown in Plate IV and constitutes the "vein."

Samples collected across the entire width of the vein in many places are reported to have shown a copper value of from 1.5 per cent to 5 per cent, with from a trace to \$2 per ton in gold.

This vein, while during part of its course is following the schistosity of the country rock, is as a whole apparently following a fracture trending about 15° or 20° east of north and approximately parallel with the North vein.



PHOTOGRAPH OF SMALL PORTION OF TYPICAL "SLATE VEIN," SHOWING ORE FILLING
CREVICES IN RIFTED SCHIST, MILLER VEIN, GOLD HILL MINE.

More interesting than these is the North vein, which does not outcrop at the surface and which was not known to exist prior to this work. This is a well-defined, mineralized and silicified band in the slates, as well defined as any vein in the district, and varies in width, vein matter and ore from 2 to 8 feet, averaging perhaps 3 feet. The ore was found to carry high gold values and very little copper, the gold running from \$10 to \$385 per ton, with less than 1 per cent of copper. Drifting was continued along the strike of the vein for considerable distance, and it was found that the rich portion was an ore shoot about 60 feet long, and also that the vein was following a fracture which cut the strike of the schistosity of the country rock at an acute angle, having a more northerly trend than the schistosity. A rise was made at the northeast boundary of the shoot and a winze was sunk at the southwest extremity, and these gave strong evidence that the shoot has about the same southwest pitch as those in the Randolph vein. The drifting along the vein encountered two diabase dikes, each about 10 feet wide, that cut it nearly at right angles, producing no displacement, and, as far as could be determined, had had no decided influence upon the values of the ore. Stringers of ore at one or two places were seen to be leaving the general trend of the vein and entering the walls in a direction parallel with the strike of the schistosity. These were not followed by the drifting. The ore from this vein is remarkably rich in free gold, the greater part of the gold being carried by the pyrite. The relation of the gold to the pyrite and other gangue minerals in this vein has been described in detail on page 37.

Some conclusions and surmises reached as a result of detailed study of the veins and ores in the mine, and of the ores in the laboratory, are summarized below.

1. That the rich ore shoot of the upper workings of the Randolph vein has pinched out.

2. That instead of there being one main vein well mineralized, there is a series of small and medium-sized veins irregularly distributed throughout the schists.

3. That there are clearly two types of veins: one highly silicious and somewhat quartzose and showing considerable replacement of the country rock by both silica and ore, the other presenting a series of narrow stringers of ore filling fissures which have been formed by splintering or tearing apart the schists along their planes of parting.

4. That the veins may be expected to extend to great depths, the Miller vein being as well developed at a depth of 800 feet as at the 160-foot level. The Randolph vein also persists and is well defined, only

having decreased in width and value. Assays made from both the 160 and the 800-foot levels of the Miller vein show similar values in both copper and gold.

5. That the veins relatively high in copper values will probably be low in gold, and that when high in gold they will probably be low in copper; that is, that some of the veins are predominantly copper-bearing, while others are predominantly auriferous. The Miller vein is predominantly chalcopyrite, while the North vein carries very little chalcopyrite, but high values in free gold in both the quartz and the pyrite. This has been discussed in detail on pages 36 and 42.

6. That the free gold in the pyrite in the North vein is not the result of secondary alterations by oxidizing waters, the pyrite being perfectly fresh and showing no trace whatever of secondary alterations. This depth—800 feet—is certainly 400 feet greater than the oxidized zone has reached in any other veins in the district. The gold, therefore, is believed to have been deposited in the pyrite originally as free gold, and to have been brought up from the unknown depths by the waters which produced the silicification of the country rock at the vein.

7. The fact that one vein is predominantly copper-bearing and another predominantly auriferous leads the investigator to suspect that there were two periods of mineralization, and if not two periods of mineralization, at least two sources for the mineralizing solutions.

8. The fact that the North vein with high gold value does not outcrop at the surface and has not been cut by the upper workings, suggests that there may be a large quantity of gold ore in the portion of the vein between this depth and the surface. The fact that the vein does not outcrop at the surface also leads to the belief that there is possibly a considerable future to mining in the Gold Hill district, and that systematic prospecting legitimately done is certainly warranted in many places in the courses of the veins that have been supposedly worked out at one place and which are known to have greater linear extension.

The Barnhardt and Miller shafts.—These shafts have already been discussed and there is little to be added. They are situated about 500 feet southeast of the Randolph shaft and are presumably on the same vein, but probably in two distinct ore shoots. The ores from each shaft are similar and occur in somewhat the same way. The vein is a "slate vein," that is, a mineralized and silicified band in the country rock, the vein rock differing from the country rock only in the degree of silicification. In some places in this vein there is little or no silicification, the vein consisting of the splintered and torn apart schists with the ore filling the spaces between the shreds or rock. The walls show

well-developed slickensides in many places and there are numerous little stringers of ore in the rocks near the main vein. These sometimes follow the schistosity, and at others follow fractures that cut it at an acute angle, having generally a trend more to the northward than the schistosity.

It is in this vein that the diabase dike mentioned on page 35 occurs. Careful examination of the ores in close proximity to the dike failed to show that it had had any apparent influence upon their character. The dike came up to the vein in the foot wall, followed it for a short distance, crossed it and then disappeared in the hanging wall.

The workings on the lower level of the Barnhardt shaft had not been extended far enough to give much information as to the character of the Miller ore shoot at the place where it was intersected by the drift. It is certain, however, that these two shafts are each in an ore shoot, and that the Barnhardt shoot pitches to the southwest approximately parallel to the *stria* on the slickensided walls of the vein, and it is believed that the Miller ore shoot has a similar pitch.

The "Old Field" Workings.—This group of prospects and shallow shafts lies a few hundred feet to the southwest of the Barnhardt shaft, apparently on the southwest continuation of the same mineralized zone. They were filled with water at the time of examination and were inaccessible. The work has extended only to water level, but it is said that a considerable quantity of free gold was obtained from them. No large and well-defined vein is reported, but only numerous narrow stringers of ore in a comparatively narrow space in the country rock.

The Gold Hill Copper Company is fairly well equipped for handling the ores. The shafts are in good repair and are furnished with good hoisting machinery. The general equipment consists of a mill with 40 stamps, amalgamating plates and Wilfley concentrators. They have a good boiler house and machine shop and dynamo and air compressor.

The Union Copper Company's Mines.—This company is operating two mines and has opened numerous prospects in the Gold Hill district. The mines in operation are the Union and the Old Honeycutt, now known as "No. 12."

The Union Mine, shaft No. 3, of the company, is, with the exception of the Gold Hill Mine, the most extensively developed in the State. The shaft has been sunk to a depth of about 600 feet and extensive workings have been made on five levels. One large lens or shoot of ore extending from the surface to the seventh level has been practically worked out. This ore body was an irregular lens-shaped mass over 100 feet long, possibly 50 feet in greatest width, and extended from

the surface down to the seventh level of the mine, about 500 feet. This ore body presented some rather suggestive irregularities of form, as may be seen by referring to the plan of the workings here given.

It will be seen that the open cut, the sub-level, the first and a portion of the second level, present an ore body with a trend which cuts the schistosity at a low angle, schistosity being about N. 40° E. while the trend of the ore body of these three levels is approximately N. 25° E. In the south end of the second level it will be seen that a portion of the ore body has a trend of nearly 65° E. of N. It will be seen that the third level presents an ore body with a trend approximately parallel with the strike of the schistosity, and, in addition, there is a small ore body near the north end of this level having a trend N. 35° W. A few feet south of this there is another small deposit of ore with a trend parallel with the schistosity.

It is clear from a detailed examination of all the underground workings that the ore bodies have been developed in a fault zone in which the hade and strike have been very irregular. It appears, therefore, that probably the vein, the open cut, the first and sub-levels and a portion of the second level is following a fracture roughly parallel with the strike of the Gold Hill fault, and that the abrupt turn in the trend of the ore body in the south end of this level is caused by the development of this portion of the ore body in a cross-break, a fracture extending across the schistosity and connecting the ore body as it is found on the third level where it follows the schistosity with that end of the third level which is clearly following a fault with a strike of about N. 35° W. This sketch also shows plainly that the ore shoot has a decided pitch to the southwest. It was interesting to note in this case, as in the Gold Hill Mine, that the strike of the slickensided walls were inclined strongly to the southwest, approximately parallel with the pitch of the ore shoot.

The small shoot of ore trending N. 35° W. was also encountered on the first level. The size and trend were the same as on the third level. This line, N. 35° W., is one of very prominent jointing throughout the whole district, often presenting slickensided walls and is very frequently followed by dikes. The Cline Mine and the Dan Hopkins digging are situated on well defined and well mineralized quartz veins, having a parallel trend in this direction. The subject of faulting has been discussed in detail (page 27). If the irregularities of these veins be compared with the sketch showing the general type of faulting for the district, it will be seen that this, together with the direction of movement indicated by the slickensides, will explain the irregularities here encountered.

The ore of this mine is a low-grade copper ore and consists of chalcopyrite with pyrite, a little sphalerite and some galena, the relation of the sulphides being the same as that at the Gold Hill Mine. (See page 36.) The ore always yields a small gold value, rarely over \$1 per ton, and is worked as copper ore. Panning shows that the greater part of the gold is present in the ore as native gold. The vein matter consists of fragments of silicified country rock, a small amount of secondary reddish-brown, semi-translucent quartz, together with much silicification of the adjoining schists. The ore occurs both in the quartz and in the altered schists. The average run of the vein is about $2\frac{1}{2}$ per cent. to 3 per cent. of copper, but the ore is "bunched" in the vein so that it may be raised to 8 to 10 per cent of copper by hand-cobbing.

The methods of mining used in working out the large ore body in the upper levels by means of square-set timbering has been described in detail in the report for 1907.*

The mine is fairly well equipped; the shaft and the machinery in general are in good repair. The company has no concentrating plant and the ore is all shipped after being hand-cobbed.

There are numerous old prospects on other mineralized bands or veins in the immediate vicinity of the Union Mine, but they had all been abandoned and were filled with water and hence inaccessible. Their location and the trend and character of the vein, as far as they could be determined, are indicated on the detailed map of Gold Hill (Fig. 2).

The Honeycutt shaft, now known as No. 12, is located a short distance west of the Old Field diggings and is apparently on the westward continuation of the same mineralized zone. This mine was opened in the early days of mining on Gold Hill, and is said to have produced considerable free-milling gold ore. Like the other veins of the district, as depth increased the sulphides were encountered and the work was abandoned. Another vein lying at about 100 feet northwest of the Honeycutt vein was also prospected in the early days, but it was found to carry principally copper and only a little gold. It is now being worked from shaft No. 7. The vein is narrow and unpromising, but is well defined and apparently follows the strike of the schistosity. It is interesting to find here a repetition of the conditions at the Gold Hill Mine, two veins close together, one carrying a gold value with little copper and the other with little or no gold.

The Whitney Company's Mines.—These mines were not in operation at the time the field work was in progress. They were therefore inaccessible and little can be said about them. Three shafts have been sunk,

*The Mining Industry in North Carolina During 1906, Economic Paper No. 14, N. C. Geological and Economic Survey. Joseph Hyde Pratt, p. 26, et seq.

the deepest one to a depth of 700 feet. Much underground development has followed and it is reported that there are a million and a half tons of gold ore averaging about \$2.50 per ton now blocked out. (See Pl. V.)

They were formerly known as the McMackin and the Isenhour mines. They are located a short distance to the west of Little Dutch Buffalo Creek and on rather low ground, but clearly in the Gold Hill fault zone and only a short distance east of the greenstone contact, all the mines lying in the tuff area and not in the greenstone.

The vein, as far as could be determined, is the ordinary "slate vein"; that is, it consists of auriferous pyrite interleaved with the schists, the ore filling narrow spaces parallel with the schistosity—really the opened planes of schistosity of the rifted schists. In character and mode of formation it does not differ essentially from the Miller vein of the Gold Hill Mine, except that in the Whitney vein there appears to have been a concentration of gold rather than of chalcopyrite, as in the Miller vein. Judging from the material on the dump, both veins have been developed in precisely the same way, probably by the force of the crystallization of the pyrite in opening and widening spaces in the planes of schistosity as it was being deposited. Much of the gold seems to have been deposited in a similar manner, many specimens of the ore showing the thinnest films of gold—almost like gold leaf in the planes of schistosity of the rock. From accounts of the ores in the copper portions of the vein, it seems that a larger percentage of the gold occurred in this manner. The pyrite, which contains a small amount of chalcopyrite, also carries free gold, as all the concentrates show when panned.

This "vein" has an almost continuous outcrop for a distance of nearly two miles. Many little pits have been sunk in it in various places and each one is reported to have shown more or less gold, none of them showing very high values. As regards its length and continuity of outcrop, it is probably the strongest single "vein" in the Gold Hill district. (See sketch map, Fig. 2.)

From data and drawings furnished by the company, it appears that the values in the vein or ore shoot are very irregular. It was not possible at the time of the field work to examine the ore body, the mine being filled with water, but it appears from reports by the engineer in charge of the exploration and test work done at the mines, the late Mr. W. J. Parker, that the ore is concentrated in certain layers or "floors" in the vein delimited by joint planes. To state it in other words, it seems that the joint planes being favorable for circulating solutions, they have to a great extent controlled the concentration of the ores,



VIEW OF THE WHITNEY COMPANY'S MINE, GOLD HILL, ROWAN COUNTY, N. C.

especially the gold. In one report on file in the company's office, Mr. Parker says: "I have surveyed the 370-foot stope in the Whitney Mine and will send you a drawing of it in a few days. The ore shoot in this stope follows a so-called floor or slide, which is in reality a bedding or structural plane of the slates. These bedding planes all over the mine undulate considerably, but, taken as a whole, dip to the northeast. This individual flow is lying nearly flat in the stope, and for this reason goes over the top of the 370-foot north drift north of the rise. When within 30 feet (vertical depth) of the 260-foot level (in the rise), another bedding plane is encountered and above this there is but very little gold.

"It seems that all the better ore in this mine is confined to certain strata of the slate, and the reason that the ore is only 5 to 20 feet wide in these strata is because all the gold has been segregated to within that space."

When it is known that the schistosity of the slates (tuffs) corresponds to their bedding planes, a fact which Mr. Parker apparently did not recognize, it is quite evident that by "floor," "slide," "structural plane" and "bedding plane" he is referring to the numerous nearly horizontal joint planes which are so prominently developed in the vicinity of Gold Hill.

The ore in this vein, as in all others of the district, lies in fairly well defined shoots, the Air shaft being located in one and the Isenhour in another, but the amount of work thus far done is not sufficient to warrant any statements as to pitch and general character of these ore shoots. In regard to the width of the vein and value of the ores †Mr. Pratt and Mr. Steel say: "The vein varies from 3 to 4 feet wide to 25 feet, and Mr. E. B. C. Hambley, the manager of the Whitney Company, assumed an average of 14 feet. His engineer (W. J. Parker) reported a million and a half tons of ore blocked out. As the vein was more definitely proved to be of value, the prospecting shafts were sunk larger so that they can be easily changed to three compartment shafts and the mine equipped for an output of 1,000 tons a day. Part of the vein is very low grade, less than \$1 a ton, but this shows occasional rich spots and cannot well be left. In the more quartzose parts there are some rich shoots or lenses 50 to 100 feet across of as high grade as \$14 to \$16 per ton.

"During the development work ore from the various drifts and cross-cuts was tested in the old McMackin mill of 10 stamps with chlorination annex. Tests made of 4,950 tons gave per ton of ore: Free gold \$0.51

†The Mining Industry in North Carolina During 1906, Economic Paper No. 14, N. C. Geological Survey, 1907, p. 46.

to \$38.75, average \$4.52; gold in concentrates per ton of ore \$0.10 to \$0.83, average \$0.34; gold in tailings per ton of ore \$0.31 to \$2.75, average \$0.83. The ore yielded from 1.83 to 12.87 per cent. of concentrates which had an average value of only \$4.17 per ton. Chlorinating the concentrates gave an average gold recovery from them of \$3.33 per ton and a loss in the tailings of \$0.84. The amount of gold amalgamated was 79.44 per cent., while that recovered from the concentrates was only 4.78 per cent. of the total value of the ore. They will therefore not bother with concentration, but merely save as much gold as possible by amalgamation. Cyaniding has not been investigated as yet, but will hardly pay on tailings which will be so low grade.

"There was a special report for each mill test, naming the place from which the ore was taken and all details. By careful sampling in the mine, they have figured that the ore will give an average recovery of \$2.50 per ton, but in the same proportion as that tested. On the basis of 1,000 tons per day, Mr. Parker expected to mine the ore for \$1.03 per ton, transport it to the mill for 12 cents and mill it for 26 cents, total expense, \$1.42 per ton, showing an expected profit of a little over \$1 per ton. Of course, this involves equipment for electric hoist and haulage plant, etc. They will use double-deck cages, since the slaty ore is expected to give trouble in loading skips. It was Mr. Hambley's intention to push the development work only fast enough to keep a half million tons of ore blocked out. He states that the vein can be followed on the surface for a distance of 2 miles, but it is very probable that there are a good many barren spots along this length, and at the north end of the old Isenhour workings there seems to have been a number of small, richer deposits pretty badly scattered. The whole mine was quite dry, especially at depth. Mr. Hambley and others said that the Isenhour vein was 9 feet thick and of good grade, and it is over 6,000 feet from the other workings."

The Southern Copper and Gold Mining Company.—The mines of this company consist of two shafts and an old prospect and a few pits along outcropping of two and possibly three veins or mineralized areas in the schists. They are located upon a hill a few hundred yards southwest of the Randolph shaft.

One shaft and the old prospect hole are probably on the same vein, which appears to have the same trend as the schistosity, while the other is on a vein lying almost 200 feet to the southeast.

The rock in which the two veins occur is very different in texture, thus showing well the variations that are met with in the country rock. The rock at the shaft and old prospect is light in color and very fine and dense in texture and is either a fine tuff much silicified or a mashed

rhyolite, while that at the other shaft, the shaft nearest the boiler house, is a typical mashed, coarse-grained tuff. The ore in this shaft is also very different from that in the former and consists of auriferous pyrite and chalcopyrite with small amount of sphalerite and galena in a silicified and quartzose portion of the country tuff. There is considerable evidence of replacement of the schists by the ores and by quartz. This ore, while not so rich as that in the north vein of the 800-foot level of the Randolph vein, in general appearance does not differ essentially from it. It clearly belongs to the silicious type of vein.

The shaft on this vein is about 200 feet deep and drifts are now being driven at right angles to the trend of the vein with the intention of exploring two more so-called veins that lie near the main vein, one to the northwest of it and the other to the southeast.

The ore in the other shaft, the one nearest the mill, consists for the most part of sphalerite, galena and pyrite, with more or less chalcopyrite, all the sulphides being auriferous, in narrow seams in the country rock, the opened up planes of schistosity. There is apparently little or no replacement of the country rock either by ore or quartz, and the vein is apparently of the rifted schist type. The ore and the country rock of this vein resemble very closely the ore and rock of the Silver Hill Mine.

A few hundred tons of the upper and decomposed ore have been hoisted and milled. The values are said to have been high, but the gold was reported to be "rusty" and not to amalgamate well.

Aside from air tools, the mine is fairly well equipped. There is a small, well-built mill equipped with ten stamps, amalgamating plates and Wilfley tables.

The Barringer Mine.—This mine, situated near Misenheimer station and about 4 miles southeast of Gold Hill, was opened prior to 1824* and was probably the first mine in the State to be opened upon a true gold-bearing vein. It was probably the discovery of this vein that caused prospecting for other veins in the "gold country" to be begun. Prior to its discovery, all the gold was thought to be only in the placer workings.

The vein is located in the "slates" at the contact with a mass of igneous rock-diabase, probably a large diabase dike, and differs from the other veins of the district in that the gangue mineral was largely calcite. The vein is said to be very narrow. A 3-inch seam in the vein is reported to have been nearly one-half pure gold, and the values throughout the vein are reported to have been very irregular, varying in assay value from about \$2 to more than \$500 per ton. The vein is also said

*A Report on the Geology of North Carolina. Denison Olmstead, Raleigh, p. 34.

to have been much disturbed by faulting. It has been estimated that nearly \$100,000 have been taken from the one ore shoot of the mine. The workings of the mine have been very irregular and much money was spent in trying to find more ore like that of the upper levels, but with little success. The plans and elevation made from surveys of the mine, now in the office of the Whitney Company, the owners of the mine, show the character of the work and the relation of the vein to the wall rock and the diabase dike.

GREENSTONE TYPE.

Southwest of the Whitney Mine the zone of mineralization passes into the greenstone area, and in this formation occur numerous small veins which have a distribution similar to those of the Gold Hill type, many small veins in parallel and closely spaced fractures. These veins have the same general northeast trend as those at Gold Hill, but in character and kind of ore and gangue of material they differ radically from the type.

The ores consist of bornite and chalcocite in a quartz and epidote gangue. The veins are usually well defined and may be easily traced on the surface by the *débris* of quartz and epidote. At times they consist only of stringers of the ore in narrow fractures in the rock, the rock showing more or less epidotization. This is so radically different from the Gold Hill type of deposit that one appears to have entered an entirely different region the moment he passes from the "slate" deposits into those of the greenstone.

Little prospecting has been done on these veins and consequently little could be learned as to their character. The prominence of the outcroppings depends upon the character of the vein material. Quartz and epidote veins have very prominent outcroppings, while those with little or no gangue materials are inconspicuous and possibly consist of a slightly prominent exposure of the rock only with copper stainings. Generally they are considered as "copper veins" rather than "gold veins," although they all carry a small value in gold.

In character these veins are exactly like the "Virgilina" type of vein. The definition given by Mr. W. H. Weed† for this type of southern copper deposits is equally applicable to these. He says: "The first type of deposit is that of a true fissure-vein, the quartz vein, formed by the filling of open cavities, with only minor and accessory replacements of country rock. The Virgilina deposits are representatives of this type. The ore is glance and bornite with little or no chalcopyrite or pyrite."

†Types of Copper Deposits in the Southern United States. W. H. Weed, Trans. Am. Inst. Min. Eng., Vol. 30, p. 452.

Some of the prospects in veins of this type are as follows: two shallow shafts on the Barringer plantation a short distance southwest of the Isenhour Mine; several shallow pits on land belonging to George P. Kluttz; the Harkey diggings near Five Pines, and the "Hopkins Mines" near Foil's mill. In all of these the veins appear to be small and unpromising.

THE CLINE TYPE.

This type of deposit differs from the greenstone only in the gangue minerals and the ore, the character of vein being the same. The ores in this type consist of auriferous pyrite and chalcopryrite in a gangue of quartz, calcite and siderite, and associated with varying amounts of specular hematite. This type occurs in both the greenstone and the diorite near their contact.

Only two prospects have been opened, neither of which was accessible during the field work; little, therefore, can be said about them. The two examples are the Cline Mine and the Dan Hopkins diggings near Cross Roads.

Both prospects are said to have contained considerable gold. Little work has been done at either, but the trenching and cross-cutting, as well as the shafts, show well-defined veins varying in width from 2 to 4 feet and trending N. 35° W.

THE DUTCH CREEK TYPE.

This type is similar in all respects to the Cline type except that the veins occur in the granite.

The ore consists of auriferous pyrite with a small amount of chalcopryrite in a gangue of quartz, with a little siderite. The prospects of this type are the Dutch Creek Mines, the Gold Knob Mines and the diggings in the vicinity of Garfield. They are all, except the Dutch Creek prospects, long since abandoned, but it is said that in the early workings considerable gold was obtained. The trend of the vein or stringers appears to be invariably toward the northeast.

The Dutch Creek Mines.—These are simply prospects belonging to Mr. A. H. Graf, of Salisbury. Several years ago a considerable amount of prospecting was done in this vicinity and three or four shallow shafts were sunk upon the richer veins. A small mill was erected and it is reported that considerable gold was secured in the upper workings from the shafts and from pits. The veins are narrow and irregular, but the ores are reported to have carried high gold values.

Recently Mr. Graf has reopened one of the most promising of the old shafts. The shaft was sunk so as to intersect a small vein outcropping on the surface and having a rather flat, southeast dip, about 45°. The ore shoot at the surface, while the values were exceptionally high,

was short and narrow. As it was followed downward, the values still remained good and the shoot lengthened and widened very materially, until, at a depth of about 60 feet, it has a width of from 3 to 6 feet and was about 60 or 100 feet long. The vein is in the granite at the contact with a decomposed basic dike which appears to be a gabbro. The ores consist of free gold in pyrite with a little chalcopyrite. The values are high and it appears as if there may be a small but valuable deposit of ore at the place. The work has not been extensive enough to warrant any very definite statements as to the value of the deposit.

PRODUCTION.

At the beginning of the year 1907 the outlook for the production of copper in the State was for a considerable increase during the year over that of the previous year, but on account of the financial depression that occurred during the last six months of 1907, there was a falling off in the actual production of copper. The copper produced in 1907 was obtained from Rowan, Person, Granville and Davidson counties, given in the order of the value of their production, and amounted to, approximately, 11,011 tons of ore, and the value of the copper content was \$116,416. This is a decrease of \$19,413 in value and of 718 tons in quantity as compared with 11,729 tons valued at \$135,829, the production of 1906. From the 1907 tonnage there was produced 597,878 pounds of copper as compared with 703,775 pounds obtained from the ore produced in 1906, a decrease of 105,897 pounds. This large decrease in pounds of copper obtained as compared with the relatively small decrease in tonnage is due to the fact that there was shipped from the Blue Wing Mine a considerable tonnage of copper ore from the dumps where it had been thrown during previous mining when the price of copper was at a much lower figure. Some of this ore shipped did not run over 2 per cent. copper, but at the high price of copper during the early part of 1907, it made a profitable ore to ship from the dumps.

There is given in the following table the production of copper ore, the amount of copper obtained from this and its value for the years 1900 to 1907, inclusive.

PRODUCTION OF COPPER FROM 1900 TO 1907.

Year.	Crude Ore Mined.	Copper Produced.	Value.
	<i>Tons.</i>	<i>Pounds.</i>	
1900	6,948		\$ 41,600
1901	10,398	512,666	76,900
1902	16,741	1,417,020	212,553
1903	4,106	458,133	67,037
1904	4,250	306,000	36,600
1905	10,000	488,888	88,000
1906	11,729	703,775	135,829
1907	11,011	597,878	116,416

IRON.

North Carolina contains numerous deposits of iron ore, but they represent resources of the future rather than available sources of income at the present time. There are but few of the iron ore deposits in the State that are capable of being developed and operated profitably at the present time, this being due to the price of pig iron and the distance of the ores from furnace and from sources of supply of fuel and flux. There is one property, however, in the State that has been a nearly constant producer of iron for the past twenty years, although some years the production has been very slight. This is the Cranberry iron mine, at Cranberry, Mitchell County. This mine produces a pig iron of exceptional quality and usually it commands a higher price than ordinary pig iron. The ore mined is a magnetite.

PRODUCTION.

During 1907 the production of iron ore in North Carolina amounted to 75,638 tons valued at \$113,488 at the mine. This ore was all obtained from Mitchell County. As compared with the production of 56,057 tons, valued at \$75,638, the 1906 production, it is an increase of 19,581 tons in quantity and of \$37,850 in value. The following table gives the production of iron ore in North Carolina from 1900 to 1907, inclusive:

PRODUCTION OF IRON ORE IN NORTH
CAROLINA, 1900-1907.

Year.	Amount Long Tons.	Value.
1900-----	21,000	\$ 42,000
1901-----	2,578	4,997
1902-----	34,336	62,771
1903-----	82,851	78,540
1904-----	64,347	79,846
1905-----	56,282	70,352
1906-----	56,057	75,638
1907-----	75,638	113,488

TIN.

There continues to be considerable interest in the tin mines of the State, and during the past year there has been a certain amount of development work done in Lincoln County by the Piedmont Tin Mining Company and at some of the properties in Cleveland and Gaston counties. There was a small amount of tin concentrates produced and shipped during 1907, but as the producer does not wish to have these figures given publicity, the production is only included in the total production.

ABRASIVE MATERIALS.

There is still a demand for corundum and the users of this abrasive are in the market for new sources of supply. Since the development of the deposits in Canada, the price of corundum has been lowered so that it is now quoted at from 5 to 7½ cents per pound, as compared with 10 cents when the mineral was formerly mined rather extensively in North Carolina. The best known deposits of this mineral in the State are those at Corundum Hill and Ellijay Creek, Macon County, and Buck Creek, Clay County, and are still controlled by the International Emery and Corundum Company of New York, who have not, however, done any work on these properties since they purchased them. On account of the uncertainty of the cost of production of corundum and its abrasive value, purchasers of properties containing this mineral are not willing to put up any large amount of money on options, and any one owning such a property would do well, in attempting to dispose of same, to make rather liberal options to any purchaser who is willing to develop the property to ascertain its value. The corundum deposits of the State are described in detail in Volume I of the Survey publications.

Garnet is another abrasive material that is mined to some extent in North Carolina. While the demand for this type of abrasive is somewhat limited, there is still a good market for a superior quality of garnet, which is used principally in the manufacture of garnet paper for the boot and shoe trade.

The other abrasive material produced in North Carolina is millstones, which are made in Rowan County from a granitic rock.

PRODUCTION.

The total value of the production of abrasive materials in North Carolina during 1907 was \$15,469, including garnet and millstones. In the following table there is given the production of abrasive materials from 1901 to 1907, inclusive:

PRODUCTION OF ABRASIVE MATERIALS, 1901-1907.

Year.	Corundum.		Garnet.		Millstones.		Total Value.
	Quantity.	Value.	Quantity.	Value.	Quantity.	Value.	
	Tons.		Tons.		Pairs.		
1901	325	\$ 48,840	775	\$ 43,000			\$ 91,840
1902			280	10,040	50	1,425	11,465
1903			*403	12,250	63	902	13,152
1904			*202	6,586	208	6,590	13,085
1905	41,150	9,000			196	2,652	11,652
1906					205	4,100	4,100
1907							\$15,469

*Including production of corundum.

†Including production of garnet.

‡Including corundum, garnet and millstones.

MICA.

Mica is one of the minerals for which North Carolina is especially noted, and this mica has been known as "standard mica" from the time it was first put on the market. It is a superior quality of mica for practically all purposes except in electrical work. For use in such apparatus the phlogopite variety gives fully as good satisfaction and in some instances better.

North Carolina continues to be the largest producer of mica in the United States and, during the past year, it amounted to about five-eighths of the total production of this country. It is, however, but about one-fourth of the total value of mica that is imported into this country each year.

PRODUCTION.

The total value of the production of mica in North Carolina in 1907 amounted to \$225,206, consisting of 645,221 pounds of sheet mica valued at \$209,956 and 1,371 short tons of scrap mica valued at \$15,250. This is only an increase of \$4,200 in value, but a decrease of 155,219 pounds valued at \$205,756, the production of 1906. The scrap mica produced in 1907 is an increase of 242 short tons in quantity and of \$3,310 in value as compared with the production of 1,129 tons valued at \$11,940 in 1906. This is an average of \$11.12 per ton for the scrap mica.

One noticeable change in the mica industry in the State is that there is more of the mica manufactured in North Carolina than formerly and more of the scrap mica is ground in the State. This means that a proportionally larger price is received for the mica in North Carolina where formerly the rough blocks or "thum trimmed" mica was shipped out and manufactured into the forms desired for use outside the State.

The 1907 production of mica was obtained from the following counties, named in the order of the value of their output: Mitchell, Yancey, Macon, Jackson, Haywood, Transylvania, Ashe, Lincoln and Watauga. Stokes County, which was a producer in 1906, reported no production in 1907.

There is given in the following table the approximate value and distribution of the production of sheet mica by counties for the years 1902 to 1907, inclusive:

PRODUCTION OF MICA IN NORTH CAROLINA DURING 1902-1907, BY COUNTIES.

County.	1902.	1903.	1904.	1905.	1906.*	1907.*
Ashe -----	\$-----	\$ 1,000	\$-----	\$-----	\$ 4,000	\$ 1,500
Buncombe -----	250	300				
Caldwell -----			10,000			
Haywood -----	20,000	18,000	34,500	33,710	15,975	17,000
Jackson -----	5,700	5,500	924	7,900	20,399	31,625
Lincoln -----					210	300
McDowell -----	600	1,000				
Macon -----	4,000	3,500		1,500	47,866	34,525
Madison -----				90		
Mitchell -----	28,203	29,000	21,500	17,950	51,540	76,846
Stokes -----	1,000	7,500			731	
Transylvania -----	750	500		600	11,275	3,500
Watauga -----				350	916	30
Yancey -----	21,150	20,000	34,000	38,800	64,284	59,880
Total -----	81,653	86,300	100,724	100,900	217,696	225,206

*In 1906 and 1907 the values by counties include the value of both sheet and scrap mica.

The next table gives the value of the total production of mica, including both sheet and scrap, for the years 1900 to 1907, inclusive:

PRODUCTION OF MICA IN NORTH CAROLINA,
1900-1907.

Year.	Sheet Value.	Scrap Value.	Total Value.
1900 -----	\$ 65,200	\$ 36,262	\$101,462
1901 -----	79,849	14,200	94,049
1902 -----	81,653	2,219	83,872
1903 -----	86,300	2,400	88,700
1904 -----	100,724	3,410	104,134
1905 -----	100,900	3,375	104,275
1906 -----	205,756	11,940	217,696
1907 -----	209,956	15,250	225,206

In order to show the ratio of the production of mica in North Carolina to the total production in the United States and the value of the imports, there is given in the next table figures covering these points for the years 1903 to 1907, inclusive:

PRODUCTION OF MICA IN THE UNITED STATES AND
IN NORTH CAROLINA AND THAT IMPORTED
INTO THE UNITED STATES FROM 1903-1907.

Year.	Production in N. C.	Production in U. S.	Import.
	Value.	Value.	Value.
1903 -----	\$ 88,700	\$ 143,128	\$ 317,969
1904 -----	104,134	120,316	263,714
1905 -----	104,275	178,588	403,756
1906 -----	217,696	274,990	1,042,608
1907 -----	225,206	392,111	952,259

As is seen from the above table, the amount of mica imported is very largely in excess of that produced in this country, showing that the demands for this mineral are increasing and that any good mica deposit is worthy of development.

Value of mica.—Mica varies quite widely in value according (first) to the quality and (second) to the size of the sheet that can be cut. The average price per pound of the North Carolina mica was 32.5 cents, the prices ranging from a few cents to about \$3 per pound for the larger sheets. The value of scrap mica has steadily increased, and in 1907 the average value per ton received for this form of mica was \$11.12. This mica represents the small particles of badly broken or shattered blocks, ruled mica, etc., obtained in mining and the waste obtained in cutting the sheet mica. This latter form of scrap mica is usually of greater value than that obtained in mining on account of its being cleaner, clearer and freer from impurities.

QUARTZ (Flint).

Quartz is a mineral that is used for a great variety of purposes, such as in the manufacture of pottery, where the quartz is used to diminish shrinkage and also in the glaze. There is one point that must be taken into consideration regarding the quartz used for this purpose and that is, it must be very free from any iron-bearing mineral. In general, quartz for this purpose must not contain over one-half of one per cent. of iron oxide. It is also used very extensively in the manufacture of glass, and here again the percentage of metallic oxides must be very low, hardly more than traces, in order that the glass manufactured may be perfectly clear and colorless.

On account of its hardness, which is 7, quartz is used extensively in the manufacture of sandpaper, in scouring soaps and powders, metal cleaners, etc. The very finely ground or powdered quartz is used to some extent as a substitute for pumice by dentists in connection with their work. Another use of the finely powdered quartz is in the manufacture of a wood filler. For the manufacture of sandpaper the massive quartz, which has to be crushed, thus giving the resulting quartz grain a sharp, cutting edge, is much superior to the quartz sand which is rounded and, even when crushed, only has a portion of its edges sharp. This quality is also objectionable in the use of sandstone for this purpose on account of the grains of quartz in the sandstone being rounded.

Another extensive use is as a flux in copper smelting, and there are a number of smelters that are purchasing large quantities of this mineral for this purpose.

Massive quartz in the form of blocks is used in the chemical industry as a filler for acid towers. It is for these last two purposes that practically all of the quartz mined in North Carolina is used.

If pottery or porcelain industries can be established in North Carolina to utilize the kaolin and other grades of clay in the State, there would be a demand for a considerable quantity of the quartz that occurs in Piedmont and western North Carolina.

PRODUCTION.

The production of quartz in North Carolina in 1907 amounted to 4,226 short tons of crude quartz valued at \$1,664. This is a decrease of 16,737 tons in quantity and of \$10,914 in value, as compared with 20,963 short tons valued at \$12,578, the production of 1906. In the following table there is given the production of North Carolina for the years 1901 to 1907, inclusive:

PRODUCTION OF QUARTZ IN NORTH
CAROLINA, 1901-1907.

Year.	Quantity.	Value.
	<i>Tons.</i>	
1901 -----	3,000	\$ 7,500
1902 -----	4,500	11,250
1903 -----	29,462	36,827
1904 -----	32,972	36,269
1905 -----	32,648	13,659
1906 -----	20,963	12,578
1907 -----	4,226	1,664

BARYTES.

The barytes industry in North Carolina is not a large one, although the quality of the barytes produced is equal to any. It is hard and compact and usually very free from iron stains. Its hardness and compactness make it a little more difficult to grind than the softer varieties.

PRODUCTION.

The production of crude barytes in North Carolina in 1907 amounted to 5,785 tons valued at \$18,855, which is an increase of 2,445 tons in quantity and of \$8,835 in value, as compared with 3,340 tons valued at \$10,020, the production of 1906. This production was obtained from Madison and Gaston counties, there being one producer in each county.

In the following table there is given the production of barytes in North Carolina for the years 1901 to 1907, inclusive:

PRODUCTION OF CRUDE BARYTES IN
NORTH CAROLINA, 1901-1907.

Year.	Quantity, Short Tons.	Value.
1901 -----	6,890	\$20,865
1902 -----	14,679	44,130
1903 -----	6,885	21,347
1904 -----	13,413	33,930
1905 -----	5,545	21,670
1906 -----	3,340	10,020
1907 -----	5,785	18,855

MONAZITE.

One of the most important events in connection with the monazite industry during the past year has been the extension of the monazite area into Alexander County, where commercial deposits of this mineral have been located and purchased by the National Light and Thorium Company. It is interesting to note the extension of the monazite area since this mineral was first mined in the Carolinas in 1893, when it first became a real industry in the State. At that time the known monazite field was an area of about 2,000 square miles in Burke, Catawba, Cleveland; Gaston, Lincoln, McDowell, Polk and Rutherford counties in North Carolina and extending into Spartanburg and Greenville counties, South Carolina. Now the area is known to cover approximately 3,500 square miles, including, besides the above-named counties, portions or all of Alexander, Caldwell and Iredell counties in North Carolina, and Anderson, Cherokee, Laurens, Oconee and Pickens counties in South Carolina. The discovery in 1907 of the Alexander County monazite deposits is the direct result of prospecting by the National Light and Thorium Company of Youngstown, Ohio.

The commercial deposits of monazite in North Carolina are the gravel beds in streams and bottom lands and in certain places the surface soils which adjoin gravel deposits. Mill tests and laboratory tests have been made upon the monazite-bearing rock, but thus far no deposit has been discovered that could be mined profitably. Occasionally certain portions of the saprolitic rock in close proximity to the gravel beds, especially that immediately underlying them, has been scraped up and washed, giving a small margin of profit. The monazite in these gravel beds has resulted from the alteration and erosion of the monazite-bearing rocks and this mineral has been concentrated by nature in these gravel deposits. The percentage of monazite in the sands extending from sur-

face to bed rock is not over one per cent. per cubic yard. This, however, is sufficient to make profitable mining. In many localities it has been the custom to sluice not only the gravels but all the overburden, inasmuch as even the top soil carries a small amount of monazite. There are no large hydraulic plants in operation, but nearly all the monazite is obtained in sluice boxes fed by hand. (Pl. VI, A.) These boxes are fitted at their upper end with a sieve or shaking hopper with a screen of about No. 12 mesh. The boxes vary in length from 8 to 20 feet and in some instances are fitted with riffles holding mercury for catching the gold.

The concentrates from these sluice-boxes have to be dried before they can be treated on the magnetic separators. There are two different methods used in the monazite district for this purpose. In one the sand is spread over an oil or rubber cloth in a thin layer and exposed to the heat of the sun. It dries very quickly, due, perhaps, to the heat absorbed by the dark iron sand. It requires, however, a considerable surface to accommodate any large amount of sand. The other method of drying is by heating over a furnace. A small ditch is dug from 4 to 8 feet long, $1\frac{1}{2}$ feet wide and about 1 foot deep, at one end of which is built a rock or brick chimney. The ditch is usually built up of stones with an opening at the opposite end of the chimney for firing. Over the ditch there is a sheet-iron cover or drying plate. The monazite is spread on this and exposed to the action of the hot fire underneath. These dried sands are often further concentrated by means of the ordinary horseshoe magnet, which picks out all the magnetite. The miners or producers of this sand are paid for it on the basis of a 100 per cent. product. The sand brought into the magnetic concentration plants is worth from 4 to 8 cents per pound. Its value is increased, however, after being run over these machines, from 12 to 20 cents per pound. This material represents what is known as crude monazite sand and contains, besides the monazite, varying amounts of magnetite, ilmenite, garnet, zircon, rutile, corundum, cyanite, quartz (occasionally), hornblende and, rarely, chromite. In order to separate the monazite from these associated minerals, it is necessary to run this crude sand through some electro-magnetic separator, such as the Wetherill, or some modification of this type of machine which is in most general use. (Pl. VI, B.)

There are many substances that are attracted by electro-magnets that are not apparently influenced at all by the strongest steel magnet, and for this reason many substances which were formerly considered non-magnetic have been proved to be magnetic when subjected to the intense magnetic field obtained in an electro-magnetic separator. All substances



A, WASHING MONAZITE GRAVEL, CLEVELAND COUNTY.



B, WETHERILL MAGNETIC SEPARATOR AT GERMAN-AMERICAN MONAZITE COMPANY'S
PLANT, OAK SPRINGS, N. C.

are, of course, either attracted or repelled by magnets, the former being called paramagnetic and the latter diamagnetic. The latter class is the most numerous, but since the introduction of the electro-magnets, the former class, which up to this time had been considered extremely small, has been largely increased. The paramagnetic substances are the metals iron, nickel, cobalt, manganese, chromium, cerium, palladium, platinum, osmium and many of their salts and compounds. The degree of attraction of these varies very widely, and thus it is possible by using the electro-magnetic separators, which can be regulated so as to give a very strong field and at the same time a field which is capable of fine adjustment, to separate not only the paramagnetic from the diamagnetic substances, but also to separate the paramagnetic from each other. As will be observed from the list of associated minerals of monazite given above, many of them are salts of the metals that are paramagnetic and it is possible by the use of the separators mentioned above to obtain a monazite sand of from 90 to 99 per cent. monazite, depending on the care that is exercised in separating it. It is the cerium in the monazite that makes it a magnetic substance.

The other products, as the iron minerals, magnetite, ilmenite and garnet, can also be obtained in a very pure state. From a long series of experiments* that have been carried on, it has been determined that when treated in the Wetherill electro-magnetic separator or a similar type of machine that magnetite can be removed with an amperage of .2; ilmenite with 1.1; chromite with 1.6; garnet with 1.75; hypersthene and olivine with 2.2; monazite with 3.5, and hornblende with 5.

USES OF MONAZITE AND ITS ASSOCIATED MINERALS.

The commercial value of monazite depends upon the incandescent properties of the rare earth oxides which it contains, such as cerium, lanthanum, didymium and thorium oxides, which are used in the manufacture of the Welsbach and other incandescent gaslight mantles. It is the thorium that is used in largest amount and which gives the actual value to the monazite. In the reduction of the monazite sand, there are a long series of salts that are obtained in considerable quantity, which have made it possible to carry on extensive series of experiments with these rare earth oxides. It requires from 4 to 6 months to recover from the monazite sand its percentage of thorium and render it sufficiently pure to be used in the mantles.

The Welsbach light consists of a cylindrical hood or mantle composed of a fibrous network of the rare earths, the top of which is drawn to

*Min. Res. U. S., Geological Survey, 1905.

gether and held by a loop of asbestos or platinum wire. When in use, this mantle is suspended over the flame of a burner constructed on the principle of the Bunsen burner, in which the heating, instead of the illuminating power of the hydrocarbon of the gas, is used by burning it with an excess of air. In this manner the mantle becomes incandescent and glows with a brilliant and uniform light.

A short description of the method of manufacture of these mantles may be of interest. The first part of the process is the selection of the thread or fiber from which the mantle fabric is knitted. The fiber mostly used is cotton, either the Upland, River Bottom, Peeler, Allen Seed, Sea Island or Egyptian variety, the market price varying from about 10 cents for the Upland to 30 cents per pound for the Egyptian. The cheaper cottons are used in the lower grade mantles, the highest grade mantles requiring the best quality of cotton. The thread is purified so as to remove every possible trace of mineral matter. If the thread used shows a mineral impurity above .015 per cent., it will introduce factors that will affect the physical and lighting life of the mantle. Cylindrical networks of varying diameters are knitted out of the thread and then washed in ammonia and distilled water and wrung out in mechanical clothes wringers. After it is dry, it is cut into pieces sufficiently long to make two good mantles.

These knitted fabrics are then placed in a suitable vessel and covered with the "lighting fluid." They remain in this until thoroughly saturated. The excess of fluid is drawn off and the fabric put through an equalizing machine piece by piece. The "lighting fluid" is composed of a solution of approximately 99 per cent. thorium nitrate and 1 per cent. cerium nitrate in distilled water, in the ratio of 3 parts of water to 1 part of mixed nitrates. The fabric is dried and then cut to the proper length required for a hood. They are then shaped over a wooden form and the upper end drawn together by means of an asbestos cord, but occasionally of platinum wire. After the mantle has been modeled, the cotton fiber is eliminated by heating them over a hot Bunsen burner flame, leaving the mantle composed of the ash of thorium and cerium. The peculiarity of these oxides is that they have sufficient cohesion to hold together during the balance of the process of manufacture, after every bit of the supporting cotton thread has been burned away. During a series of tempering and testing heats, the mantle is carefully shaped to its permanent form. In order to protect the ash of the mantle during its inspection, packing, transportation and installation, it is dipped in collodion.

Just before using the mantle the collodion covering has to be burned off. It is estimated that the American market consumes at least 40,000,000 of these mantles per year.

Another element obtained from the monazite is didymium, whose oxide is dark brown. Use is made of this for branding the mantles with an indelible brand. A nitrate solution is made and an ordinary rubber stamp used for branding.

Of the associated minerals, zircon has a considerable commercial value of 20 to 25 cents per pound for its zirconia content, which is used in the manufacture of the glower of the Nernst lamp. The fundamental principle of this Nernst lamp is that certain of the rare earths or refractory oxides will conduct an electric current and glow after they have been heated to redness. This discovery, which was made by Dr. Nernst in 1897, has resulted in the development and perfecting of the glower which is now embodied in the Nernst lamp. This glower is composed of a mixture of the rare earth oxides and is made in the form of a small rod or pencil of chalk-like material, having wire terminals at either end. When cold, the glower is an insulator, but by means of the wire the glower becomes heated to redness when a current is passed through these wires, and its resistance gradually decreases until it has reached a red heat, when with 220 volts across the terminals, it starts to conduct the current and give light.

In bringing a glower up to its starting point corresponding to a temperature of 1,200° F., use is made of a small electrical heater composed of two or more small tubes of porcelain about 1½ inches long and ¼ inch in diameter, which are overwound with fine platinum wire, this being in turn held in place and protected from the intense heat later generated by the glower by an outer coating of porcelain paste. After the glower becomes heated, there is, of course, no further use for the heater, and it is cut out by a small electro-magnet cut-out, which consists of a magnetic coil connected in series with the glower, an armature and the necessary contacts in the heater circuit. Thus, when the glower has become heated sufficiently, the current begins to pass through it, and when this becomes sufficiently strong, the armature is attracted and the contacts are separated, thus disconnecting the heater from the line. The surface of the glower, before being used, presents a smooth, white, porcelain or chalky appearance, but, after having been in use about 500 hours, it is rough or crystalline in appearance.

The yttria contents used in the manufacture of the Nernst glower are obtained principally from the mineral gadolinite, which has not thus far been found in the State.

The magnetite and ilmenite may find a use in the manufacture of magnetite electrodes that are manufactured by the General Electric Company.

The garnet grains are sharp and can be used for abrasive purposes in the manufacture of garnet paper, which is used extensively in the boot and shoe trade.

PRODUCTION.

There was a large falling off in the production of monazite in North Carolina during 1907 compared with 1906 on account of the continued low price of thorium nitrate, which caused a reduction in the price of monazite sand from 20 to 12 cents per pound for the refined sand. This decrease in price made it impossible for a number of the monazite properties to be operated at a sufficient profit to warrant their being worked. The production amounted to 456,863 pounds valued at \$54,824, as compared with 697,275 pounds valued at \$125,510, the production of 1906, this being a decrease of over 100 per cent. in value and approximately 50 per cent. in quantity. This production was obtained from Cleveland, Rutherford, Burke, Iredell, Alexander and Catawba counties, given in the order of the importance of their production. This production of North Carolina is five-sixths of the total production of this mineral in the United States. One company, the British-American Monazite Company, which was a producer in 1906, closed out and sold their property and machinery. This is the company that attempted to mine the monazite-bearing rock, but found it to contain too low a percentage of monazite, although they had no difficulty whatever in obtaining a very clean product.

In the table below there is given the production and value of monazite mined in North Carolina from 1893 to 1907, inclusive:

PRODUCTION OF MONAZITE IN NORTH
CAROLINA. 1893-1907.

Year.	Monazite.	
	Pounds.	Value.
1893	130,000	\$ 7,690
1894	546,855	36,193
1895	1,573,000	137,150
1896	30,000	1,500
1897	44,000	1,980
1898	250,776	13,542
1899	350,000	20,000
1900	908,000	48,805
1901	748,736	59,262
1902	802,000	64,160
1903	773,000	58,694
1904	685,999	79,438
1905	894,368	107,324
1906	697,275	125,510
1907	456,863	54,824

ZIRCON.**PRODUCTION.**

There was but a very small production of zircon in North Carolina in 1907, amounting to only 204 pounds valued at \$46. This was obtained from the Jones Mine, in Henderson County, which is the mine that has produced all the zircon sold during the past ten years. In the following table there is given the production and value of zircon mined in North Carolina from 1902 to 1907, inclusive:

**PRODUCTION OF ZIRCON IN NORTH
CAROLINA FROM 1902 TO 1907,
INCLUSIVE.**

Year.	Pounds.	Value.
1902 -----	2,000	\$ 380
1903 -----	3,000	570
1904 -----	1,000	200
1905 -----	8,000	1,600
1906 -----	1,100	248
1907 -----	204	46

TALC AND SOAPSTONE.

There continues to be a large demand for a quality of talc such as is found in Swain County and is now only produced by the North Carolina Talc and Mining Company at Hewitt. This is an exceptional quality of talc and the deposits cannot supply the demand for this talc to be used in the manufacture of tailors' pencils, gas tips, etc. The State has been pretty well prospected for similar deposits, but thus far none have been located, although large deposits of other qualities of talc suitable for grinding into talcum powder, for the manufacture of soapstone tubs, etc., are known.

Where formerly practically all of the talc mined in North Carolina was shipped out of the State, there is now a certain quantity of the ground talc utilized within the State by the Talcum Puff Company of Asheville, who are manufacturers of talcum powders. They produce their own talc in Swain County, and, on account of the purity of the talc, they are able to put on the market an exceptional quality of talcum powder.

PRODUCTION.

During 1907 there was produced 4,085 short tons of talc and soapstone valued at \$74,347. This is a decrease of 99 tons in quantity but an increase of \$7,368 in value as compared with 4,184 tons valued at \$66,979, the production of 1906. This increase in value with a decrease in tonnage is due to the better quality and higher priced articles

manufactured from talc in 1907. This production was obtained from Swain, Moore, Jackson and Alleghany counties, given in the order of the value of their productions.

As there is very little talc sold in the crude state, the values are for the production as it was marketed and usually represents the manufactured product. In the table below there is given the condition in which the 1907 production was marketed together with the productions for 1905 and 1906:

PRODUCTION OF TALC AND PYROPHYLLITE IN NORTH CAROLINA DURING
1906 AND 1907.

Condition in Which Marketed.	1905.		1906.		1907.	
	Quantity, Short Tons.	Value.	Quantity, Short Tons.	Value.	Quantity, Short Tons.	Value.
Ground talc for powders, etc. -----	3,529	\$ 39,007	2,094	\$ 19,925	2,245	\$ 24,514
Talc cut into pencils, gas tips, etc. -----	205	32,568	1,020	35,688	160	43,034
Talc sold crude -----	301	8,115	895	11,116	1,580	5,999
Soapstone cut into slabs for chimneys, etc. -----		250		250	100	800
Total -----	4,035	74,940	4,009	66,979	4,085	74,347

In the following table the quantity and value of talc and soapstone produced in North Carolina from 1898 to 1907 is given:

PRODUCTION OF TALC AND SOAPSTONE IN NORTH CAROLINA,
1898 TO 1907, INCLUSIVE.

Year.	Quantity.	Value.	Year.	Quantity.	Value.
	<i>Short Tons.</i>			<i>Short Tons.</i>	
1898 -----	1,695	\$ 27,320	1903 -----	5,331	\$ 76,984
1899 -----	1,817	31,880	1904 -----	3,801	65,483
1900 -----	4,522	75,308	1905 -----	4,035	74,940
1901 -----	5,819	77,974	1906 -----	4,184	66,979
1902 -----	5,239	88,962	1907 -----	4,085	74,347

PRECIOUS STONES.

There was but very little systematic mining for gems in North Carolina during 1907, and a number of the well-known gem localities were not operated at all. The gem material produced during the year included ruby, emerald, beryl, hiddenite, quartz, amethyst, rutile, cyanite, feldspar and garnet. There was one piece of milky opal reported as having been found in Iredell County. Brief notices of some of the gem material found and properties operated are given below, and have been taken from the report of Mr. Douglas B. Sterrett, of the U. S. Geological Survey.*

*The Production of Precious Stones in 1907. Advance Chapter, Mineral Resources of U. S. Geological Survey for 1907.

*Ruby.**—Interest in the ruby deposits along Caler Fork of Cowee Valley, Macon County, N. C., has been revived through operations of the United States Ruby Mining Company. This company has undertaken to develop the ruby in the matrix lead previously located at "In Situ Hill" in the valley, and expects to wash the ruby-bearing gravels left unworked during former mining operations. For a distance of over 2 miles rubies have been found in the creek gravels, much of which has been worked. The gem-bearing gravels lie both above and below the company's headquarters at the mouth of Dalton Branch. Good rubies have been found in the creek gravels about a mile above the mouth of Dalton Branch as far as "In Situ Hill." This hill is merely the end of a ridge or spur which extends from the mountains on the south side of the valley down close to the creek.

In the report of Mr. C. Barrington Brown, in 1896, to the American Prospecting and Mining Company on the ruby mine of Cowee Valley, the rubies are described as generally of good color, many resembling the true pigeon-blood ruby of Burma. Some of them have bluish borders, which give them a magenta tint. Pratt and Lewis† state that some large gems—3 or 4 carats in weight—of good color and transparency and free from inclusions, have been found. Though found in less quantity, the color and quality of these stones equal the Burma rubies. Some of the Cowee Valley rubies contain inclusions of rutile, ilmenite, garnet, etc., or are silky or badly flawed. Much pink and red corundum, some of it approaching the ruby in color and quality, is associated with the ruby. The concentrates obtained in washing for ruby contain red, pink, bluish, gray, and yellowish corundum, ilmenite, rutile, cyanite, red and pink or rhodolite garnet, small zircon crystals, quartz, feldspar, etc. In the New York office of the United States Ruby Mining Company an admirable display of ruby and ruby corundum, as well as specimens of ruby matrix material, has been arranged by Mr. Alfred H. Smith.

During 1907, Mr. N. E. Isbell, of the United States Ruby Mining Company, constructed a new ditch to carry the creek from above "In Situ Hill" along the opposite hillside, where it could be tapped for pressure for hydraulic purposes. This ditch was extended to a point opposite the mouth of Dalton Branch, where a fall of nearly 100 feet could be obtained to hydraulic the bottom lands below. Another reason for the construction of the ditch was the hope that by turning the creek from its bed close to "In Situ Hill" the flow of water in the shaft on the ruby matrix would be diminished and the surrounding

*Ibid., pp. 24 and 25.

†Pratt, J. H., and Lewis, J. V., *Corundum and the Peridotites of Western North Carolina*: N. C. Geol. Survey, Vol. 1, 1905, pp. 180-186.

mud become harder. A 20-horse power engine with a rotary centrifugal pump and bucket elevator were installed to assist in sinking the shaft and driving a crosscut from the bottom through the soft ground.

The matrix in which the ruby corundum occurs, and in which genuine rubies are said to have been found, consists of hornblende gneiss and pegmatite in hornblende gneiss. The pegmatite occurs in small streaks and lens-shaped pockets from an inch or two to a foot thick, roughly conformable with the bedding of the enclosing hornblende gneiss. Both the pegmatite and the hornblende gneiss are very badly decomposed at the surface. The feldspar of the pegmatite has largely passed into kaolin, while the hornblende gneiss has altered to the yellowish brown earth characteristic of the saprolite of that rock, with hydromica and black spots where small garnets have rotted away throughout. That this weathering extends to a depth of over 30 feet is shown by the material removed from a shaft of that depth. The strike of the country rock at "In Situ Hill" is north of east, with a high dip to the southeast. A dike of hard, unaltered hornblende eclogite outcrops in the bottom of the valley, a few feet north of the ruby matrix, and can be traced to the east and west some distance. The hornblende gneiss, saprolite, contains parallel streaks of mica-gneiss saprolite included in it.

In some of the pockets of decomposed pegmatite translucent pink to lilac colored corundum is very abundant, both in fairly large well-formed crystals and in small fragments. Red and ruby-colored corundum is less plentiful, and but few crystals of gem quality have been found in the pegmatite bodies so far. Portions of the hornblende saprolite enclosing the pegmatite carry small translucent corundum crystals and fragments, some of rich red color in small pockets of soft white material. These were probably small masses of pegmatite which have decomposed, though they might possibly represent the decomposition products of former corundum crystals. From the few specimens of matrix seen by the writer, it appeared that the corundum associated with larger bodies of pegmatite is inclined to be of a lighter color—pink or lilac—than the richer red stones in the hornblende rock alone, or where pegmatite is less prominent.

Emerald, beryl, and hiddenite.*—Emerald was obtained from three places in North Carolina during 1907. The greater part came from the emerald-hiddenite mine and the Ellis emerald mine, already described under beryl. Of the remainder, part was found at a prospect belonging to Mr. W. H. Warren, 1 mile north of Hiddenite, and part consisted of emerald matrix from Mitchell County probably mined some years ago and recently cut.

*The Production of Precious Stones in 1907. Advance Chapter, Mineral Resources of U. S. Geological Survey, pp. 10, 11 and 19.

Regular mining for aquamarine and the beryl gems was carried on in North Carolina during 1907 at Hiddenite. Scattered lots were brought in by mica miners and prospectors in other parts of the mountain country, chiefly in Mitchell and Yancey counties, though some were obtained in Iredell County and at Barretts Mountain, Alexander County.

The hiddenite and emerald mine, one-half mile west of Hiddenite, Alexander County, was reopened and worked during part of the year by Mr. Cary Wright for the American Gem Mining Syndicate. At the same time Mr. Wright opened a new prospect called the Ellis emerald mine, one-fourth mile east of Hiddenite. The work was stopped in September, 1907, pending the installation of a power plant for larger operations. Aquamarine and beautiful specimen beryl, emerald, and hiddenite were obtained in promising quantities. Mr. Wright mentions one beautiful specimen, 2 inches long by $1\frac{1}{2}$ inches in diameter, weighing over 750 carats, obtained from the emerald-hiddenite mine. It was translucent with prism faces highly polished. Many aquamarine crystals of from 10 to 20 carats were found in the same mine. Several fine crystals of aquamarine were found at the Ellis mine, two of which were imbedded in transparent quartz crystals, making splendid cabinet specimens. Emeralds of fine color were obtained from both mines. At the Ellis Mine one dark-green emerald weighing 276 carats was found. About 200 carats of hiddenite were obtained from the emerald-hiddenite mine. One crystal, weighing about 10 carats, was one-half colorless and the other half a deep emerald green. Jet black tourmaline crystals associated with feldspar; clear, colorless, smoky, and rutilated quartz crystals; rutile crystals, etc., were also found associated with the beryls.

At the emerald-hiddenite mine there are a large number of veins generally striking north of east with high dips to the north. For a distance of over 50 yards both to the north and to the south of the main workings a number of pits and several shafts have been made on different veins. In all of the veins opened quartz crystals were found, some very clear and beautiful, with well-developed crystal form. Some of these openings yielded beryl or hiddenite, occasionally of gem quality.

The old workings at the emerald-hiddenite mine were made chiefly between 1880 and 1885, and consisted of a large open cut, with two shafts near the western end, besides numerous smaller test pits in the vicinity of the open cut. The open cut is situated near the top of a low ridge and is probably 150 feet long, 20 to 40 feet wide, and 15 to 20 feet deep. A haulway had been cut to the same level at the east

end to the dump. The new work in 1907 consisted of an open pit, some 12 feet wide and 18 feet long, near the eastern end of the old cut and at the north side of the haulway. Two well-defined veins were found in this cut, and also two less promising ones. These veins were nearly parallel, and the strike measured on the best one was N. 70° E., dip about 85° N. Several good, though small, pockets were found in this cut.

The country rock in the region around the emerald-hiddenite mine and the Ellis emerald mine is chiefly biotite gneiss, garnetiferous in places, which has been much compressed and folded, probably while in a plastic condition. Veinlets of quartz in the original rock have been folded and crumpled during this compression into forms resembling folded ribbon. The country rock in the neighborhood of the veins has been highly silicified by the addition of much quartz. This quartz along with other minerals, as muscovite, rutile, pyrite, etc., has replaced the biotite and feldspars and other minerals of the country rock. This replacement was later than the compression of the rock and about contemporaneous with the deposition of the vein matter. These phases are beautifully illustrated in hand specimens which show typical biotite gneiss with folded quartz veins, several feet from a vein, and in similar rock, highly silicified, with a portion of the vein-filling adhering. In the latter specimen the vein filling a fissure is glassy quartz with calcite, rutile, and pyrite inclusions. The wall next to the vein consists largely of granular quartz and an emerald-green (chrome) muscovite, with a little rutile and pyrite. At about 1 inch from the vein the replacement of the country rock is not so complete, and biotite becomes gradually prominent in the rock. At 2 inches from the vein the rock is nearly black biotite gneiss, rich in quartz. A folded quartz veinlet cuts the gneiss to the vein wall. It is more prominent in the black gneiss than in the highly replaced gneiss, though it can readily be traced through the latter, since the quartz of which it is composed was not so easily replaced as certain constituents of the gneiss. Some of the rock cut by the veins contains much chlorite and has a yellowish-green color.

The material filling the gem-bearing veins consists of quartz, calcite, dolomite, muscovite, rutile, black tourmaline, aquamarine and emerald beryl, hiddenite, pyrite, chalcopyrite, and monazite. All of the veins in the neighborhood do not contain all of these minerals, but each of the numerous veins exposed in the workings contain some or all of them. In the cavities all of these minerals occur in crystals; in solid-vein matter certain ones only have crystal form. The calcite was introduced after the other minerals had been deposited, in many

places filling up previously existing cavities. Crystals of the other minerals are embedded in solid calcite veins, and calcite has been deposited between broken fragments of beryl and other crystals. Rutile suitable for cutting is plentiful in brilliant crystals, some long and slender, others short and thick. The crystals are commonly twinned, several crystals often joined or crossing each other at angles of 60° , forming beautiful cabinet specimens of rosettes or reticulated masses of needles. The gem minerals—emerald, aquamarine, and hiddenite—occur in distinct crystals in the veins, and when lining the walls of cavities and of good color they make a beautiful contrast with the associated gangue minerals.

The vein at the Ellis emerald mine is pegmatite, with cavities and pockets included in it. The pegmatite strikes N. 50° E., with a high northerly to vertical dip. There are stringers or arms of pegmatite along the walls, and at one place the pegmatite is composed along one side largely of small mica blocks. The country rock is biotite gneiss, small dikes of quartz diorite being included. The latter weathers out in rounded boulders or "nigger heads," which are scattered over the surface near the mine. The quartz in portions of the pegmatite is a fairly dark rose color. So far, however, none suitable for gem purposes has been found.

Amethyst.*—In Macon County, N. C., amethyst has been found at various places in the region of Tessentee Creek, near Scaly Mountain, and to the south of Highlands. The amethyst of this region occurs in veins cutting granite gneiss and mica gneiss. The veins in which the amethyst occurs are generally irregularly filled, well-defined fissures cutting the enclosing rocks at variable angles, though generally with a high dip. Some of these veins have been traced several hundred feet. Deep-colored amethyst crystals are found in pockets in these veins, often associated with pale amethystine and colorless quartz crystals. The spaces between the crystals are commonly filled with red clay or other earthy material. The pockets range from a fraction of an inch to 15 or 18 inches in thickness, and may extend several feet along the vein. The crystals range in size from a small fraction of an inch to 3 and 4 inches across. In some of the crystals the purple color of amethyst is entirely lacking or present only in pale shades. In others the rich purple of Siberian amethyst is present. The color is generally most intense near the points of the crystals and often occurs in planes parallel to the crystal faces. This renders only portions of the crystals suitable for cutting, although much amethyst and quartz suitable for specimens only is obtained.

*Ibid., p. 7.

PRODUCTION.

The value of the production of precious stones of all kinds in North Carolina for the year 1907 was \$7,580, as compared with \$5,000, the value of the 1906 production, this being an increase of \$2,580. This production was obtained from Alexander, Macon, Iredell, Mitchell and Yancey counties, given in the order of the estimated value of their output. It has been impossible to obtain accurate figures regarding the production of precious stones, as there is a good deal of material brought in to different dealers in precious stones who keep no record whatever of the material so purchased.

In the table below there is given the production of precious stones in North Carolina for the years 1900 to 1907, inclusive:

PRODUCTION OF PRECIOUS STONES IN
NORTH CAROLINA SINCE 1900.

Year.	Value.
1900	\$ 12,020
1901	24,245
1902	5,300
1903	1,525
1904	10,600
1905	3,350
1906	5,000
1907	7,580

MINERAL WATERS.

INTRODUCTION.

Although the mineral water industry in the State is not at the present time of very great value, there is a possibility and probability of its developing into an industry of very great value to the State in two ways: First, by the bottling and shipping of the various mineral waters for medicinal and table uses; and, second, by using them in connection with hotels where the medicinal value of the water is desired by the guests.

There are scattered throughout North Carolina hundreds of mineral springs of greater or less value from a medicinal standpoint. Some of the springs contain little or no solid matter or gases, but, on account of their great purity, are of value as table water.

It is absolutely necessary, in order to create a market for mineral water, that it not only be a pure water, especially adapted for table use or containing some ingredient or ingredients that make it of special medicinal value, but it is also very necessary that the water be very widely advertised. If it is to be put on the market in pint, quart or gallon receptacles, too much attention cannot be given by the producer

to the neatness and general appearance of the bottle and label. There are but few of the springs whose waters, up to the present time, have been put on the market to any large extent.

There exists in many counties throughout the State springs and wells having a local and, in some cases, a widespread reputation for their medicinal properties, and there are still many others as yet in nowise developed and but little known that will become commercial springs. Although the present work on the mineral waters is but preliminary, it should aid in drawing attention to and extending the reputation of the springs of real value and stimulating the investigation and development of new mineral waters of genuine merit.

It is almost impossible to give a definition for mineral water that will cover every case, for the reason that any natural water that is utilized as an article of commerce, except public water supplies, would be brought under this head if it contained any mineral matter which gave it especial medicinal value or if it was an absolutely pure water which made it of special value for table use. Thus, the water may come from a well, a spring or even a lake and may contain one part or one thousand parts of solid in solution in each 1,000,000 parts of water.

The mineral waters described beyond were, in most cases, collected by some member of the Geological Survey and sealed and shipped by express or freight to the laboratory at Chapel Hill. At the same time the agent of the Survey made such observations as were possible regarding the rate of flow, temperature, escape of gases, odor, character of surroundings, etc. The analyses have for the most part been made at the laboratory of the University of North Carolina, and unless otherwise stated have been made by Dr. F. P. Venable. The bulk of the analyses were made from 1895 to 1900, but will represent pretty accurately the composition of the spring at the present time. Not all of the valuable mineral waters in North Carolina have been analyzed or described in this report, and in selecting what springs should be analyzed and described, letters were addressed to prominent persons, usually physicians, in all parts of the State, asking for information as to any spring or well in their neighborhood which had any general or local reputation or recognized therapeutic properties. Whenever such a spring was heard of, it was visited and a sample secured for analysis. It is undoubtedly true that in selecting this limited number of springs for analysis, some have been admitted which ought to have been excluded and others have been omitted which should have been included.

COMPOSITION OF MINERAL WATERS.

Mineral waters contain quite a variety of solid compounds in solution in the water and also certain gaseous compounds. The solid matter and gases vary in the different springs not only in variety but also vary largely in quantity. Such a thing as pure spring or well water entirely free from all dissolved mineral matter is practically unknown upon the earth's surface. In the first place, rain water as it falls through the earth's atmosphere would absorb a certain amount of oxygen, nitrogen and carbon dioxide. These gases, especially the carbon dioxide, would add very materially to the solvent power of the water as it comes in contact with the earth's crust and percolates through it. Some waters may only come in contact with undecomposed and difficultly soluble rocks and would have, therefore, very little action on their mineral constituents. Other waters, however, coming in contact with some porous and easily soluble rocks, might take into solution considerable quantities of mineral matter. From the soils above the rocks the waters would take considerable solid matter in solution, this varying with the character of the soil through which the water percolated. Waters that have penetrated to great depths and have become subjected to greater pressure and are at a higher temperature have their solvent power increased and are apt to contain much more mineral matter than the surface waters. The principal constituents of the mineral waters are not the most abundant ingredients of the earth's surface, but are principally the elements most needed by plants for their growth. The different elements that have been found in the various mineral springs are: Hydrogen (H), Lithium (Li), Sodium (Na), Potassium (K), Magnesium (Mg), Calcium (Ca), Strontium (Sr), Barium (Ba), Boron (B), Aluminum (Al), Carbon (C), Silicon (Si), Nitrogen (N), Phosphorus (P), Arsenic (As), Oxygen (O), Sulphur (S), Chlorine (Cl), Manganese (Mn), Bromine (Br), Iodine (I), Iron (Fe), Cobalt (Co), and Nickel (Ni). Of the above elements, all but strontium have been reported in some of the springs of North Carolina. Just how these elements are combined in the various mineral waters is not known and many opinions are held regarding the relative probability of their formation. It is, therefore, impossible to separate out and bring into a weighable form each of the compounds which may be present in the mineral water. Thus, there may be several different compounds of calcium in the water, but it is impracticable to separate them and they are, therefore, reacted upon and all of the calcium precipitated as the oxalate and the calcium determined as calcium oxide. In reporting it as calcium oxide, it does not mean that it is present as such, but is in reality combined with one or more

of the acid radicles. Again, the sulphuric acid radicle may be combined with several of the basic radicles and there might be in solution in the water sodium sulphate, potassium sulphate, magnesium sulphate, calcium sulphate, etc. The chemist cannot separate these various sulphates, but precipitates all the sulphuric acid present as the insoluble barium sulphate, which can be weighed and from which the sulphuric acid radicle (SO_3) is calculated. Thus, each basic and acid substance is separated, precipitated and weighed and reported as "found," although, strictly speaking, it is not found nor does it occur in that form in the water. This is frequently misunderstood by the person unacquainted with chemistry when looking over the reports of mineral water analyses. For instance, chlorine is constantly being reported as found in a mineral water. This does not mean, however, that the free irritant chlorine gas is there, but that chlorine combined with some basic radicle does occur in the mineral water.

In reporting the analyses, Dr. Venable says: "Two statements are made: first, the amounts of the basic and acid constituents found are given and then the probable compounds formed by these bodies. With regard to this last there is much lack of uniformity among chemists in spite of the appointment of various committees to devise some satisfactory system. Very little is actually known as to these compounds and various opinions seem to be held as to the relative probability of their formation. The chemical theories as to mass action look upon the acids as portioned out among all the bases in such a way as to bring about an equilibrium. This is probably true, but as we are ignorant as to the ratios in this apportionment, it is not possible to draw up such a list of compounds. The theory of solution, which is dominant in chemistry at present, supposes the existence of the acids and basic substance as separate bodies or negative and positive ions, not definitely united, yet with properties neutralized. In accord with this theory, the United States Geological Survey has adopted the system of simply reporting such and such ions as found. This system would be quite incomprehensible to the uninitiated public. They require something more definite and nearer their every-day experience than the reporting of sodium ions and chlorine ions and sulphuric acid ions as present in the water.

"In the following reports of analyses the chief guide followed was the general consideration of the most frequently met with compounds and hence the ones most likely to be met with or present. Thus, the chlorine was taken as combined with the sodium and, if there was any excess, with the potassium and the magnesium and calcium until the

amount of chlorine was exhausted. The sulphuric acid was combined with the potassium, and if in excess with the sodium, not united to the chlorine, and if there was still excess, then with the calcium. As there is excess of carbon in nearly all of these waters, the carbonates were all calculated as bicarbonates, thus giving the magnesium and calcium carbonate in a soluble form. It is generally believed that iron is present as ferric bicarbonate, and it is so reported. Certainly the iron is not present as ferric oxide, as is reported in many analyses.

"The phosphoric acid which is present, usually in traces only, is reported as combined with calcium as calcium phosphate. This is done in preference to sodium or potassium phosphate, often reported by chemists because the calcium phosphate is more abundant and widely distributed in the soil. No surmise is ventured as to which calcium is present, though it might be assumed that it is in the form of water-soluble or calcium hydrogen phosphate.

"The silica is simply reported as such. It is quite possible that it is present, sometimes as an alkaline silicate. No conjecture is ventured along this line either, and the usual custom is followed in reporting it simply as anhydrous silica."

THE UNIT OF MEASURE IN THE ANALYSES.

The results of the analyses of the mineral waters are given in three different ways: First, the compounds found are reported in the usual way for analytical work, but represent, instead of percentage, so many parts per 1,000,000 parts of water.

In the second and third methods a hypothetical form of combination has been made of the various compounds as they are supposed to exist in solution in the water and these compounds are reported in the second method in so many parts per 1,000,000 parts of water; that is, so many mg. in 1,000,000 mg. or a liter of water. Thus, 13.5 total solids per 1,000,000 would mean that there are 13.5 mg. of solid matter in 1,000,000 cm. or one liter of water.

In the third method the compounds are reported as so many grains in one gallon of water. To illustrate, if 2.5 grains of calcium chloride per gallon were reported, it would mean that in every gallon of the mineral water there were 2.5 grains of the salt, calcium chloride. This method is given for the reason that it is used to some extent by commercial dealers in reporting the composition of their mineral water. The second method is the one in most general use.

CLASSIFICATION OF MINERAL WATERS.

One of the first differences that is noted in mineral springs is in the temperature, and they are known as thermal or nonthermal springs according as the temperature is above or below 70° F.* In some of the hot springs the temperature rises to as high as 140° F., while in some of the nonthermal springs the temperature is as low as 39°. Waters from 70° F. to 98.6° F. would be considered warm or tepid, and those above 98.6° F. would be considered hot.

A number of systems have been advocated for the classification of mineral waters, and there is given below two which are very similar and which are considered the best. One, which was proposed by Mr. A. C. Peale,† is as follows:

PEALE'S CLASSIFICATION.

Thermal or Nonthermal.	I. Alkaline.	{ Sulphated. Muriated. Borated.	{ Sodic. Lithic. Potassic. Calcic. Magnesic. Chalybeate. Aluminous.	{ Nongaseous. Carbonated. Sulphureted. Azotized. Carbureted. Oxygenated.
	II. Alkaline-saline.			
	III. Saline.	{ Sulphated. Muriated. Borated.		
	IV. Acid.	{ Sulphated. Muriated. Silicious.		
			{ Sulphated. Muriated.	

The other classification, which was reported adopted by Mr. J. K. Haywood, Chemist of the U. S. Department of Agriculture,‡ is a modification of Peale's classification and is as follows:

HAYWOOD'S CLASSIFICATION.

Group.	Class.	Subclass.		
Thermal. Nonthermal.	I. Alkaline.	{ Carbonated or bicarbonated. Borated. Silicated.	{ Sodic. Lithic. Potassic. Calcic. Magnesic. Ferruginous. Aluminic. Arsenic. Bromic. Iodic. Silicious. Boric.	{ Nongaseous. Carbondioxated. Sulphureted. Azotized. Carbureted. Oxygenated.
	II. Alkaline-saline.	{ Sulphated. Muriated. Nitrated.		
	III. Saline.	{ Sulphated. Muriated. Nitrated.		
	IV. Acid.	{ Sulphated. Muriated.		

The chief differences between Peale's and Haywood's classifications are that the four classes of thermal and nonthermal waters, *i. e.*, alkaline-saline, saline, and acid, are defined not on the basis of combinations of ions present, as is done by Peale, but on the basis of the ions themselves, since no chemical methods are known by which we can determine

*Distinction used by Dr. A. C. Peale.

†A System of Physiologic Therapeutics, edited by S. S. Cohen, Vol. 9, p. 302.

‡U. S. Department of Agriculture, Bureau of Chemistry, Bull. No. 91, 1905, p. 9.

the relative amounts of the acid and basic ions entering into combinations with each other to form salts. Also, the alkaline group in the Haywood classification contains the carbonated, borated and silicated waters, since waters are known which owe their alkalinity, at least in part, to alkaline borates or silicates.

The alkaline-saline and saline groups have been divided into sulphated, muriated and nitrated waters, since Haywood has found at least one water which contained nitrate. Then again, in the Haywood classification, all the four groups are indicated as possible silicious waters instead of just the acid group.

It is possible from these classifications to name any mineral spring so that the name will give a fairly accurate idea of the chemical composition of the spring. When any basic element is very prominent in a mineral water, the name of this base can be prefixed to the regular class name as sodic, lithic, ferric, etc.

The following scheme will be of assistance in the naming of any mineral water according to the Haywood classification:

Thermal or Non-thermal.	{	Sodic.	{	Carbonated or bicarbonated.	{	Alkaline.	{	Arsenic.	{	Nongaseous. Carbon dioxide. Sulphureted. Carbureted. Oxygenated.
		Lithic.		Borated.		Alkaline-saline.		Bromic.		
		Potassic.		Silicated.				Iodic.		
		Calcic.		Sulphated.		Saline.		Silicious.		
		Magnesic.		Muriated.				Boric.		
		Ferruginous.		Nitrated.		Acid.		Lithic.		
		Aluminic.		Sulphated.				Ferruginous, Etc.		
				Muriated.						

The commoner waters are:

Chalybeate waters.—Such waters as contain a notable proportion of a compound of iron, as ferrous bicarbonate, are properly called iron or chalybeate waters. This compound of iron is held in solution by the excess of carbonic acid in the waters. On bubbling up in a spring and coming in contact with the atmosphere this escapes as carbon dioxide and the ferrous carbonate is oxidized and changed to ferric hydroxide which is no longer soluble in the water and so is deposited as a red-brown slime in the spring or near its outlet. No matter how tightly stoppered a vessel of such a water may be, a deposit of ferric hydroxide will form in it on standing, and hence it does not bear transportation as well as other waters.

Sulphur waters.—These contain gaseous sulphureted hydrogen, hydrogen sulphide, in solution. This is supposed to come from the decomposition of certain metallic sulphides in the passage of the water through the soil. The presence of this gas reveals itself by the odor imparted to the water. The strength of the odor affords some indication as to the amount of sulphureted hydrogen present. Such waters

lose this gas, and consequently their odor, on bottling and shipping, etc., and, like the preceding class, do not bear transportation well. Many of these carry iron which is in the form of sulphate and so is not changed and deposited on standing like the ferrous bicarbonate.

Alum waters.—Some waters passing through alum shale dissolve more or less of the alum present. This imparts a very decided astringency to the water. Such waters generally contain a number of other sulphates, as those of iron and copper.

Alkaline waters.—These contain the carbonates and bicarbonates of sodium (sometimes potassium). This may be in sufficient amount to render the water strictly alkaline.

Saline waters.—Nearly all waters contain a small amount of sodium chloride or common salt. Where this predominates, or the proportions of it are exceptionally large, the water is called a saline water.

Lime waters.—Most waters contain a small amount of calcium bicarbonate. This gives to the water the property of hardness and causes the curdling or precipitation of soap. The degree of hardness is measured by the amount of calcium bicarbonate present. The effect is not very appreciable if only small amounts of it are present. Hard waters are very common in districts where there is much limestone. The presence of magnesium bicarbonate also adds to the hardness. As the hardness of such waters can be removed by boiling and other simple methods, they are said to be “temporarily hard.”

Where a water contains calcium sulphate it is called “permanently hard,” and no ordinary simple method will remove the hardness.

Magnesia waters.—The presence of magnesium chloride or magnesium sulphate (epsom salts) imparts a bitterness to the water. A large proportion of any compound of magnesium will give a magnesia water. The term is sometimes restricted to those in which magnesium bicarbonate is present.

THERAPEUTICS OF MINERAL WATERS.

It is impossible to trace the therapeutic action of each ingredient of the mineral water, for the small amount of these compounds present in the water seem to have a different action from what they do in specially prepared solutions. Some of the best results have been obtained where a very pure water has contained but one ingredient in large excess. Some of the chalybeate and sulphur springs of North Carolina are of this type, and they have proved to be most excellent waters. It is undoubtedly true, however, that the value of many of the so-called mineral waters depends largely upon their comparative

purity and the large quantities of them that invalids and others can be induced to drink while surrounded by conditions most generally favorable to rest and contentment.

In the following paragraphs there are given the physiological action and therapeutic applications of the various classes of mineral waters that have been brought together by the Bureau of Chemistry of the United States Department of Agriculture.* These results, however, were not obtained from experiments by the Bureau of Chemistry, but were taken from works which they considered authoritative on the subject.†

Carbonated or bicarbonated alkaline waters.—This is one of the most important groups of mineral waters. As a class these waters are used to stimulate the secretions of the digestive tract, neutralize superacidity of the stomach, dissolve uric acid, increase the flow of urine, and correct acidity of the urine. They are therefore of value in catarrhal conditions of the mucous membranes, rheumatism, gout, diabetes, etc.

Sodic carbonated and bicarbonated alkaline waters.—Sodium carbonate or bicarbonate appears as a normal constituent of the blood, lymph, and nearly all secretions of the mucous membrane. Where conditions arise that cause any of these fluids to become acid, this class of waters is of great value in counteracting the effect. The sodic carbonated waters increase metabolism, dissolve uric acid and allay irritation of the mucous membrane of the urinary tract. They have therefore been used with excellent results in treating acid dyspepsia, rheumatism, gout and diabetes.

Potassic carbonated and bicarbonated alkaline waters have very much the same action as the sodic carbonated, except that they are perhaps better for increasing the solubility and elimination of uric acid.

Lithic carbonated and bicarbonated alkaline waters.—While lithium seldom or never occurs in waters in large enough quantities to be a predominating basic constituent, still it does often appear in sufficient quantities to have a decided therapeutic action. These compounds are active diuretics and form a very soluble urate which is easily eliminated from the system. Waters of the above class, therefore, find their greatest application in the treatment of rheumatism, rheumatic tendencies and gout.

Magnesian carbonated and bicarbonated alkaline waters.—Such waters as these act as mild laxatives and are, perhaps, the best of all the car-

*Bulletin 91, Bureau of Chemistry, U. S. Department of Agriculture, Mineral Waters of the United States, by J. K. Haywood, 1905, page 12.

†Among these are Crook's Mineral Waters of the United States and Canada, Schweitzer's Mineral Waters of Missouri, and Cohen's System of Physiologic Therapeutics.

bonated alkaline waters in correcting an acid constipation. They favor the solution of uric acid and are used in catarrhal conditions of the mucous membrane of the urinary organs.

Calci carbonated and bicarbonated alkaline waters.—This class of waters is quite different in its effect from the carbonated waters previously mentioned. While the foregoing waters are evacuant and promote secretions, this class of waters constipates and decreases the secretions. Very obstinate cases of chronic diarrhœa have been cured by a sojourn at a spring rich in calcium bicarbonate.

Ferruginous bicarbonated alkaline waters.—These waters increase the amount of hæmoglobin and in connection therewith the temperature, pulse and weight. They also increase the appetite and reduce intestinal activity. Such waters give excellent results when used as a tonic. They find their principal application in anæmia and in general debility brought about by sexual diseases. Too long use of waters rich in iron results in constipation and derangement of the digestion.

Borated alkaline waters.—There are comparatively few springs of this description which have been used to any extent. Their therapeutic application, therefore, is somewhat obscure. It may be said in general that such waters act as anti-acids. Applied locally to catarrhal mucous membranes, they are of value.

Muriated alkaline-saline waters.—These waters are especially valuable in the treatment of catarrhal conditions of the mucous membrane of the stomach, intestines and biliary passages and urinary tract. They increase the flow of urine and the excretion of uric acid. The stronger ones are often used as a gargle.

Sulphated alkaline-saline waters.—These waters, like the preceding class, are valuable in the treatment of catarrhal conditions of the mucous membrane. They also act as diuretics. In large quantities they act as purgatives by increasing the peristaltic movement and liquefying the intestinal contents. Such waters as these are especially indicated in obesity.

Muriated saline waters.—As a whole these waters stimulate the secretion of the stomach, increase digestion, favor a more complete absorption of foods, and act as diuretics.

Sodic muriated saline waters.—When these waters are very heavily charged with sodium chloride they are often used for baths to increase the action of the skin, and by absorption act as a tonic. Such waters, when taken internally, are usually diluted. They increase the flow of gastric juice, improve the appetite, increase the flow of urine, and the urea in the same. They also prevent putrefactive changes in the intestines.

Potassic muriated saline waters.—It is not known whether there are waters which belong to the muriated saline group and yet contain potassium as a predominating constituent. However, potassium is sometimes present in these waters in considerable quantities. Its therapeutic action is very much like that of the sodium salt.

Lithic muriated saline waters.—Such waters as these would have the usual action of the muriated saline class, with an intensified diuretic effect, due to the lithium.

Calcic muriated saline waters.—These waters usually have sodium as the predominating basic constituent, along with notable amounts of calcium and sometimes magnesium. In general debility these waters act as a tonic. They increase the flow of urine and are used in the treatment of scrofulous diseases and eczema.

Sulphated saline waters.—As a class these waters are laxative or purgative, according to the quantity taken, and should generally only be used in moderate amounts. They are especially indicated where long continued stimulation of the intestinal activity is desired without stimulation of the vascular system.

Sodic and magnesian sulphated saline waters.—In small doses these waters act as laxatives and in large doses as purgatives. They increase the flow of the intestinal fluids and of the urine, the latter being accompanied by an increased elimination of urea. Such waters as these are of great service in eliminating syphilitic, scrofulous and malarial poisons from the system and in throwing off mercury and other metallic poisons. Persons suffering from obesity, dropsy, derangement of the liver, and Bright's disease are perhaps the most benefited by this class of waters.

Potassic sulphated saline waters.—While potassium may be present in large enough quantities in the sulphated saline waters to deserve mention, the authors do not know of any waters in which it is a predominating basic constituent. In so far as it is present, however, it has very much the same effect as the two salts mentioned above.

Calcic sulphated saline waters.—This class of waters forms what is known as the permanently hard group. They have no well-known therapeutic action.

Ferruginous sulphates saline waters and aluminic sulphated saline waters.—Iron and aluminum usually occur together when either is present as a predominating metallic constituent in sulphated saline waters. Since waters containing large quantities of iron and aluminum along with sulphuric acid ions are practically always acid, it is best to consider them under the sulphated acid group.

Nitrated saline waters.—The authors have only found one water which belongs to this class, and are undecided, on account of not being able to examine the surroundings of the spring, whether the nitrates are due to organic nitrogenous matter which is in active state of decomposition or to nitrogenous matter which has been oxidized in times long past and is therefore no longer injurious. In either case, however (especially in the latter), the existence of one water containing predominating quantities of nitrates necessitates a classification to cover this group of waters. The medicinal action of these waters has not been determined.

Acid waters.—This group of waters is principally composed of the ferruginous-aluminic sulphated class, although there are a few acid springs which contain comparatively little iron and aluminum, but quite large amounts of calcium, sodium or magnesium. These waters are used in relaxed conditions of the mucous membrane, especially when characterized by diarrhea or dysentery. They are also used in the treatment of exhausting night sweats and impoverished conditions of the body brought about by intemperance or specific diseases. Locally they are used in treating inflamed or relaxed conditions of the mucous membrane such as are found in conjunctivitis, chronic vaginitis, etc. The ferruginous waters of this group have the usual effect of all iron waters, such as has already been described under ferruginous carbonated alkaline waters. When a water is desired for its tonic effect it is best to give it in the ferruginous carbonated form, since it is more easily absorbed and assimilated.

Iodic and bromic waters.—Since iodine and bromine usually accompany each other in mineral waters, they should be considered together. Waters of this class act as alteratives. They stimulate the lymphatic system to greater activity and promote absorption in all the tissues. Their employment is therefore indicated in the treatment of scrofula, syphilis, goiter, chronic exudations, etc. They also favor the elimination of mercury and other metallic poisons. The bromic waters also act as sedatives.

Arsenic waters.—These waters act as an alterative, increase the appetite and digestion, and improve the whole nutrition of the body. They do this not only by increasing the secretion of the gastro-intestinal membrane, but also by checking katabolism. Such waters as these are especially valuable in the treatment of anemia and a number of skin diseases. They are also indicated in the treatment of chronic malarial poisoning, neuralgia of anemic origin, scrofulosis, etc.

Silicious waters.—The medicinal value of these waters has not been thoroughly investigated, although one or two investigations have been

made which seem to show that they would be of value in the treatment of cancer. It has been stated that silica taken internally has caused albumin and sugar to disappear from the urine.

Azotized and oxygenated waters.—Both nitrogen and oxygen are present in all waters that have come in contact with the air. On account of the limited solubility of both they cannot occur in waters in very large quantities. Neither of them as they occur in waters has any medicinal value.

Carbondioxated waters.—These waters contain free carbon dioxid as distinguished from the carbonated or bicarbonated waters which contain carbon dioxid in combination. Usually the heavily carbondioxated waters are also bicarbonated, but this is not necessarily true. Free carbon dioxid is present in practically all natural waters to some extent, but in some waters, notably the Saratoga, it is present in very large quantities. Such waters are extremely palatable, and large quantities can be drunk without causing a "full feeling." These waters tend to increase the flow of saliva and intestinal fluids, also to increase the peristaltic movements of the stomach and, therefore, increase digestion. They also tend to increase the flow of urine. Obstinate cases of nausea are often relieved by the use of this class of waters.

Carbureted waters.—These waters sometimes occur in coal and natural-gas regions. They are not known to have any medicinal value, but are usually considered unfit for drinking purposes.

Sulphureted waters.—These waters increase the action of the skin, intestines and kidneys. They also possess a decided alterative effect. They have been used in the treatment of syphilis, chronic metallic poisoning, rheumatism and gout. They have also given excellent results in many skin diseases.

LOCATION OF MINERAL SPRINGS.

In describing the mineral waters, those will be taken up first that occur in the eastern or coastal plain region, then those in the central or Piedmont plateau region, and finally those in the western or mountain region. It will be found that the distribution of the springs is quite irregular, that many are to be found in each region and also that the character of the spring varies according to the region in which it occurs. A short description is given first of the three physiographic regions into which the State is divided.

Coastal plain region.—This region represents the most recent geologic formations composed of gravels, sands, clays and marls arranged in nearly horizontal layers with the finer material nearer the coast. Along its eastern border this region contains the sounds and bays,

the sand dunes and ridges, the swamps and marshes, and other characteristics of a seashore region. Farther inland it is gently undulating and has more of the upland and less of the marsh, and towards its western boundary the swamps disappear almost entirely, the upland predominates and the surface becomes more undulating and even hilly in places. The soils toward the east are composed of fine sand and silt, while nearer the western border of the region they contain a larger proportion of coarse sand or gravel mingled with clay. The extent of this region is from Raleigh eastward to the coast, with its western boundaries roughly defined as extending from the western part of Northampton through Franklin, Wake, Cumberland, Chatham, Moore, Montgomery and Anson counties.

Along the western border of the coastal plain region there are occasional outcrops of hard granites and slates exposed along the beds of streams, where the once overlying sands and clays have been washed away. In the southeastern counties of this region limestone is exposed at the surface along the banks of streams in a large number of localities.

In this region the springs generally occur along the faces of steep slopes at the outcrop of coarse, sandy or gravelly strata. Chalybeate waters are not uncommon in portions of this region, due largely to the ferruginous character of these beds of gravel. Some of the deep wells yield saline waters owing to the fact that they have penetrated the strata carrying salt. Similarly, some of the deeper wells contain sulphur, due to the fact that these have penetrated tertiary or cretaceous strata which contain in places considerable quantities of decomposed pyrite or other sulphur compounds. The normal annual temperature of this coastal plain region is about 61° F. and the normal annual rainfall is about 55 inches.

Piedmont plateau region.—The Piedmont plateau region, extending westward from the coastal plain region to the mountain region, is about 125 miles in width and has an average elevation approximating 900 feet. Crossing this Piedmont plateau obliquely are a series of geologic formations which are in general parallel to the mountains and seashore. The most eastern of these formations is a narrow belt of triassic sandstone and shales which has a maximum width of about 15 miles, and extends from Oxford in Granville County across the State through portions of Wake, Durham, Chatham, Moore, Montgomery, Richmond and Anson counties. On the northeast of this sandstone and between it and the coastal plain region there are considerable areas of granite extending across portions of Wake, Franklin, Warren, Vance and Granville counties. To the west there is an older formation of metamorphosed slates and schists which cross through Person, Orange, Randolph,

Montgomery, Stanly and Union counties and has a general width of from 20 to 40 miles. Just west of this there is an area of granites, between which and the mountain region are gneisses, probably Archean. Near the western boundary of the Piedmont plateau region is the second of the two sandstone belts, which is much more limited in area than the one to the east and extends from the Virginia line across portions of Rockingham and Stokes counties, having a maximum width of from 4 to 5 miles.

There is a greater variety of mineral constituents in the waters of the springs of this region than in the coastal plain, owing to the greater variety of rocks and soils through which these waters percolate before becoming concentrated at certain places from which they reach the surface as springs. The average temperature of the Piedmont plateau region is about 58.5° F. and the annual rainfall is about 50 inches.

Mountain region.—The mountain region includes the Blue Ridge, Great Smokies and the country between, which is cut across by the numerous cross ranges separated by narrow valleys and deep gorges. The average elevation of this region is about 2,700 feet above the sea level, but the summits of many ridges and peaks are over 5,000 feet. A considerable number of peaks reach a height of over 6,000 feet, the highest of which is Mount Mitchell, with an elevation of 6,711 feet. Over the larger part of this region are to be found the older crystalline rocks, gneisses and granites, probably Archean, which are greatly folded and turned on their edges. On the western and eastern borders of this mountain region, approximately along the line of the Blue Ridge and Great Smokies, there are two narrow belts of younger rocks consisting of limestones, shales and conglomerates and the metamorphosed marbles, quartzites and slates.

In this region, as in the Piedmont plateau, the rocks are decayed to a considerable extent and thus have produced deep soils which vary in character according to the rocks from which they have been derived. The soils are for the most part porous and fertile, affording a luxuriant vegetation, in many places the slopes of the mountains being covered by heavy virgin forests. Where the rocks that have decomposed contained a large percentage of aluminous minerals, a large amount of clay has been formed, and such clay soils characterize a large portion of both the Piedmont and mountain regions.

The springs of the mountain region are similar to those of the Piedmont plateau. The average temperature for the region approximates 50° F., varying from 57.8° F. at Hot Springs, Madison County, to an estimated temperature for the summit of Mount Mitchell of less than 38° F. The normal annual precipitation is about 57 inches.

DESCRIPTION OF SPRINGS IN THE COASTAL PLAIN REGION.*

COWHEAD SPRING, NEAR WASHINGTON, BEAUFORT COUNTY.

The Cowhead Spring is located about 3 miles northeast of Washington, N. C., in a low, marshy space between two slight hills and also between the two prongs of a small stream which drains this area.

The flow of the spring was, at the time visited, about $10\frac{1}{2}$ gallons per minute and this is probably the minimum. There are evidences that the flow is quite variable and that at times the rate of flow is much greater than that measured. The sides of the receptacle into which the water rises are thinly coated with a flocculent deposit left by the water to a height of about one foot above the normal level, and as the discharge is through an opening in the side of the curbing, the discharge under this head would be considerably increased. This deposit varies in color from a bright yellow through various shades of yellow and orange to a dingy green. The water has a very perceptible odor and taste. When the temperature of the atmosphere was 15.6° C. in December, 1903, the temperature of the water was found to be 16.7° C.

ANALYSIS OF COWHEAD SPRING MINERAL WATER.

Name and Formula.	Parts per 1,000,000.
Potash (K_2O)	1.10
Soda (Na_2O)	12.60
Lime (CaO)	16.90
Magnesia (MgO)	31.70
Ferric oxide (Fe_2O_3)	6.20
Manganese oxide (Mn_2O_4)	7.90
Sulphuric oxide (SO_3)	1.90
Chlorine (Cl)	7.40
Phosphoric oxide (P_2O_5)	.20
Silica (SiO_2)	49.50
Total solids at 110° C.	132.00

HYPOTHETICAL FORM OF COMBINATION.

Name and Formula.	Parts per 1,000,000.	Grains per Gallon.
Sodium chloride ($NaCl$)	11.90	.69
Sodium sulphate (Na_2SO_4)	1.90	.11
Sodium bicarbonate (HN_3CO_3)	17.90	1.04
Potassium sulphate (K_2SO_4)	1.90	.11
Potassium bicarbonate ($HKCO_3$)		
Magnesium bicarbonate ($Mg(HCO_3)_2$)	114.70	6.69
Calcium phosphate ($CaH_4(PO_4)_2$)	.50	.03
Calcium bicarbonate ($Ca(HCO_3)_2$)	48.70	2.84
Ferrous bicarbonate ($Fe(HCO_3)_2$)	13.80	.81
Manganous bicarbonate ($Mn(HCO_3)_2$)	18.40	1.07
Silica (SiO_2)	49.50	2.87
Total grains per gallon		16.26

* Unless otherwise stated, analyses have been made by Dr. F. P. Venable.

HYGEIA SPRINGS, LITTLETON, HALIFAX COUNTY.

These springs are 1 mile north of Littleton, Halifax County, on the Seaboard Air Line Railway. One of these springs, No. 1, contains a much larger quantity of iron than the other and the iron oxide was the only constituent determined in this one.

ANALYSES OF HYGEIA SPRINGS MINERAL WATER.

No. 621.

Name and Formula.	Parts per 1,000,000.	
	No. 1.	No. 2.
Soda (Na_2O)		.80
Potash (K_2O)		4.50
Lime (CaO)		3.20
Magnesia (MgO)		1.00
Ferric oxide (Fe_2O_3)	14.00	4.50
Manganese oxide (Mn_2O_4)		.50
Sulphuric oxide (SO_2)		.40
Chlorine (Cl)		5.50
Silica (SiO_2)		23.70
Total solids at 110°C .	41.50	60.00

HYPOTHETICAL FORM OF COMBINATION.

Name and Formula.	Miligrams in 1,000,000 Parts of Water.	Grains per Gallon.
Sodium chloride (NaCl)	10.50	.61
Potassium sulphate (K_2SO_4)	1.40	.08
Magnesium bicarbonate ($\text{Mg}(\text{HCO}_3)_2$)	3.60	.21
Calcium bicarbonate ($\text{Ca}(\text{HCO}_3)_2$)	9.30	.54
Ferrous bicarbonate ($\text{Fe}(\text{HCO}_3)_2$)	10.00	.58
Manganous bicarbonate ($\text{Mn}(\text{HCO}_3)_2$)	1.20	.07
Silica (SiO_2)	23.70	1.38
Total grains per gallons		3.47

LAWRENCE SPRINGS, NEAR MURFREESBORO, HERTFORD COUNTY.

There are two of these springs, No. 1 and No. 2, which are $1\frac{1}{2}$ miles from Murfreesboro by road, but a shorter distance in a direct line. Spring No. 2 is 200 yards due west of No. 1. Spring No. 1 has a flow of about 2 gallons per minute, and No. 2 of about 6 gallons per minute.

ANALYSES OF LAWRENCE SPRINGS MINERAL WATER.

No. 110.

Name and Formula.	Parts per 1,000,000.	
	No. 1.	No. 2.
Potash (K_2O)	trace	.90
Soda (Na_2O)	3.20	4.60
Lime (CaO)	5.20	7.10
Magnesia (MgO)	4.00	1.90
Manganese oxide (Mn_2O_4)	3.80	2.50
Ferric oxide (Fe_2O_3)	1.60	2.20
Sulphuric oxide (SO_3)	16.60	10.50
Chlorine (Cl)	4.00	6.40
Phosphoric oxide (P_2O_5)	trace	—
Silica (SiO_2)	23.80	20.20
Total solids at 110° C.	78.00	68.00

HYPOTHETICAL FORM OF COMBINATION.

Name and Formula.	No. 1.		No. 2.	
	Parts per 1,000,000.	Grains per Gallon.	Parts per 1,000,000.	Grains per Gallon.
Sodium chloride ($NaCl$)	6.00	.85	8.70	.51
Potassium sulphate (K_2SO_4)	—	—	1.60	.10
Magnesium chloride ($MgCl_2$)	—	—	1.70	.09
Magnesium sulphate ($MgSO_4$)	12.00	.69	—	—
Magnesium bicarbonate ($Mg(HCO_3)_2$)	—	—	4.30	.25
Calcium sulphate ($CaSO_4$)	12.60	.74	6.10	.96
Calcium phosphate ($CaH_4(PO_4)_2$)	trace	trace	trace	trace
Ferrous bicarbonate ($Fe(HCO_3)_2$)	3.50	.20	5.00	.29
Manganous bicarbonate ($Mn(HCO_3)_2$)	8.50	.52	5.90	.34
Silica (SiO_2)	23.80	1.38	20.20	1.17
Total grains per gallon	—	3.88	—	3.71

FAIRGROUNDS SPRING, MURFREESBORO, HERTFORD COUNTY.

This spring is within the corporate limits of the town of Murfreesboro, which is situated on a bluff above the Herrin River and about 250 yards of the main street. It was formerly known as the Wise Spring. The spring has a flow of about 2 gallons per minute.

ANALYSIS OF FAIRGROUNDS SPRING MINERAL

No. 712.

WATER.

Name and Formula.	Parts per 1,000,000.
Potash (K_2O)	1.30
Soda (Na_2O)	23.10
Lime (CaO)	9.10
Magnesia (MgO)	2.90
Ferric oxide (Fe_2O_3)	1.90
Manganese oxide (Mn_2O_4)	4.60
Sulphuric oxide (SO_3)	5.60
Phosphoric oxide (P_2O_5)	trace
Chlorine (Cl)	18.20
Silica (SiO_2)	20.90
Total solids at 110° C.	80.60

HYPOTHETICAL FORM OF COMBINATION.

Name and Formula.	Parts per 1,000,000.	Grains per Gallon.
Sodium chloride (NaCl)	29.90	1.74
Sodium sulphate (Na_2SO_4)	8.40	.49
Sodium bicarbonate ($\text{Na}_2(\text{HCO}_3)_2$)	36.30	2.11
Potassium sulphate (K_2SO_4)	2.20	.13
Magnesium bicarbonate ($\text{Mg}(\text{HCO}_3)_2$)	10.50	.59
Calcium phosphate ($\text{CaH}_4(\text{PO}_4)_2$)	trace	trace
Calcium bicarbonate ($\text{Ca}(\text{HCO}_3)_2$)	26.20	1.53
Ferrous bicarbonate ($\text{Fe}_2(\text{HCO}_3)_2$)	4.20	.25
Manganous bicarbonate ($\text{Mn}(\text{HCO}_3)_2$)	10.40	.59
Silica (SiO_2)	20.90	1.22
Total grains per gallon		8.65

CATHERINE LAKE SPRING, ONSLOW COUNTY.

This spring is in Onslow County, about 10 miles west of Jacksonville, and is $1\frac{1}{2}$ miles southwest of Catherine Lake. The water flows from the foot of a low hill and rises in a pool enclosed by a wooden box (about 7×18 feet) with a roof over it. The water in this pool is 4 feet deep and overflows in a stream about 6 feet wide and $1\frac{1}{4}$ inches deep at the rate of 1,500 gallons per minute. The temperature of the water was 17°C . with an air temperature of 24°C .

ANALYSIS OF CATHERINE LAKE SPRING
MINERAL WATER.

No. 728.

Name and Formula.	Parts per 1,000,000.
Potash (K_2O)	.60
Soda (Na_2O)	4.30
Lime (CaO)	21.70
Magnesia (MgO)	6.20
Ferric oxide (Fe_2O_3)	3.10
Manganese oxide (Mn_2O_4)	2.50
Sulphuric oxide (SO_2)	6.50
Chlorine (Cl)	6.20
Phosphoric oxide (P_2O_5)	.10
Silica (SiO_2)	21.50
Total solids at 110°C .	115.

HYPOTHETICAL FORM OF COMBINATION.

Name and Formula.	Parts per 1,000,000.	Grains per Gallon.
Sodium chloride (NaCl)	8.10	.47
Potassium sulphate (K_2SO_4)	1.30	.08
Magnesium chloride (MgCl_2)	2.60	.15
Magnesium bicarbonate ($\text{Mg}(\text{HCO}_3)_2$)	19.60	1.14
Calcium phosphate ($\text{CaH}_4(\text{PO}_4)_2$)	.30	.02
Calcium bicarbonate ($\text{Ca}(\text{HCO}_3)_2$)	62.40	3.64
Ferrous bicarbonate ($\text{Fe}(\text{HCO}_3)_2$)	6.90	.40
Manganous bicarbonate ($\text{Mn}(\text{HCO}_3)_2$)	5.80	.34
Silica (SiO_2)	21.50	1.26
Total grains per gallon		7.50

ELLERBE SPRING, RICHMOND COUNTY.

This spring is in Richmond County 12 miles north of Rockingham. It is in a grove of oaks at the base of a hill on the south side of a creek. There are buildings to accommodate guests. The spring is enclosed with masonry and covered. The water forms in the outflow a heavy reddish-brown flocculent deposit. The water is charged with carbon dioxide, escaping bubbles of which can be noticed. It has no odor. The rate of flow is about 1 gallon per minute and a half and the temperature in the summer of 1897 was 60.8° F. (16° C.)

ANALYSIS OF ELLERBE SPRING MINERAL WATER.

No. 670.

Name and Formula.	Parts per 1,000,000.
Potash (K_2O)	2.00
Soda (Na_2O)	5.40
Lime (CaO)	20.70
Magnesia (MgO)	7.60
Ferric oxide (Fe_2O_3)	4.00
Manganese oxide (Mn_2O_4)	1.00
Sulphuric oxide (SO_3)	4.80
Chlorine (Cl)	6.00
Phosphoric oxide (P_2O_5)	2.60
Silica (SiO_2)	29.60
Total solids at 110° C.	145.

HYPOTHETICAL FORM OF COMBINATION.

Name and Formula.	Parts per 1,000,000.	Grains per Gallon.
Sodium chloride ($NaCl$)	10.20	.59
Potassium sulphate (K_2SO_4)	3.70	.22
Magnesium bicarbonate ($Mg(HCO_3)_2$)	27.70	1.60
Calcium phosphate ($CaH_4(PO_4)_2$)	.60	.04
Calcium bicarbonate ($Ca(HCO_3)_2$)	59.80	3.91
Ferrous bicarbonate ($Fe(HCO_3)_2$)	8.80	.51
Manganous bicarbonate ($Mn(HCO_3)_2$)	2.30	.13
Silica (SiO_2)	29.60	1.73
Total grains per gallon		8.73

RED SPRINGS, ROBESON COUNTY.

Near Red Springs station, in Robeson County, on the Fayetteville and Bennettsville branch of the Atlantic Coast Line Railway, 12 miles south of Fayetteville, there are numerous flowing wells and springs, the water from which is mildly chalybeate and leaves a reddish deposit of iron oxide where it discharges. The flowing wells or "springs," as they are generally called, are located from a third to half a mile north of the railway station. Half a dozen iron pipes have been driven to a

depth of 20 to 25 feet, where they penetrate the water-bearing gravels and sands, and up through these the water rises to a height of from 1 to 3 feet above the ground surface and flows at the rate of from one-half gallon to 2 gallons per minute. The water has generally a slight hydrogen-sulphide odor and a mild chalybeate taste, and its source is sufficiently deep to render it safe from ordinary surface contamination.

Located on the east side of these springs is the Red Springs Female Seminary, and on the west side is an academy for boys. Near-by hotels and boarding houses furnish ample accommodations for visitors.

Samples of water for analyses were collected in July, 1896, of water flowing from the iron pipes at springs Nos. 2 and 6, and the result of these analyses are given below.

ANALYSES OF RED SPRINGS MINERAL WATER.

Nos. 647 and 648.

Name and Formula.	Parts Per 1,000,000.	
	No. 2.	No. 6.
Potash (K_2O)	29.50	.30
Soda (Na_2O)	3.80	2.20
Lime (CaO)	2.50	2.50
Magnesia (MgO)	2.20	1.30
Ferric oxide (Fe_2O_3)	7.50	7.10
Manganese oxide (Mn_2O_3)	2.10	
Sulphuric oxide (SO_2)	1.90	1.50
Chlorine (Cl)	8.00	4.40
Hydrogen sulphide (H_2S)	trace	
Silica (SiO_2)	13.00	13.40
Total solids at $110^{\circ}C$.	102.00	47.00

HYPOTHETICAL FORM OF COMBINATION.

Name and Formula.	No. 2.		No. 6.	
	Parts per 1,000,000.	Grains per Gallon.	Parts per 1,000,000.	Grains per Gallon.
Sodium chloride ($NaCl$)	7.50	.43	4.30	.25
Potassium chloride (KCl)	7.50	.43	.50	.03
Potassium sulphate (K_2SO_4)	4.40	.25		
Potassium bicarbonate ($KHCO_3$)	43.30	2.52		
Magnesium bicarbonate ($Mg(HCO_3)_2$)	8.00	.46	4.80	.28
Calcium bicarbonate ($Ca(HCO_3)_2$)	7.30	.42		
Calcium chloride ($CaCl_2$)			2.90	.17
Calcium sulphate ($CaSO_4$)			2.10	.12
Calcium phosphate ($CaH_4(PO_4)_3$)	trace	trace		
Ferrous bicarbonate ($Fe(HCO_3)_2$)	16.50	.96	15.80	.92
Manganous bicarbonate ($Mn(HCO_3)_2$)	5.10	.29		
Silica (SiO_2)	13.00	.75	13.40	.78
Total grains per gallon		6.52		2.55

Red Springs No. 2 is located on the west side of the railway, about 300 yards north of the Townsend Hotel. The water as it flows from an iron pipe about 2 feet above ground at the rate of about 1 gallon

per minute has a slight hydrogen-sulphide odor and an iron taste. Its temperature was found to be 64° F. (July, 1896).

Red Spring No. 6.—This spring is about 100 yards north of spring No. 2 (page 94) and has the same general surroundings. It is a strong, bold spring, flowing about 4 gallons per minute. The temperature (July, 1896) was 62° F. Water is shipped both from this and spring No. 2.

PANACEA SPRING, WARREN COUNTY.

This spring is located at Panacea Springs, Warren County, about 4 miles south of Littleton, a station on the Seaboard Air Line Railway. The spring has been known since the first settlement of that section of the State and it has been supposed that the Indians valued the water for its medicinal purpose from the fact that the solid rock was hollowed out, forming a crude round basin for holding the water. It has been used by the white settlers almost continuously since it was discovered and hundreds of visitors have been visiting this spring regularly each year. There are ample hotel accommodations (see Pl. VII, A) for guests located near the spring. The new Panacea Hotel, which was built in 1908, contains 100 rooms, each of which is equipped with steam heat, lighted by electricity, and has hot and cold running water. The grounds run in connection with it cover something like 20,000 acres, a portion of which has been made into a lake covering 40 acres (see Pls. VII, B, and VIII, A), which is equipped with rowboats and canoes and well stocked with game fish. The park is headquarters for the Mosby Hall Hunt Club.

The location and equipment of the Panacea Spring Company make the place a most attractive one for the tourist as well as for those who wish to avail themselves of the spring water for medicinal purposes.

The main spring, which flows from crevices in the rock, has been carefully protected and a large basin hollowed out for holding a supply of water. A neat pavilion has been built over the spring (Pl. VIII, B). This water is being bottled and put on the market in cases of 12 half-gallon bottles. The flow of the spring is 8 gallons per minute. The waters are chalybeate and charged with a considerable amount of carbon dioxide gas. There is a deposit of iron oxide such as is usually observed from springs of this class. A complete analysis was made of the water of this spring.

Thirty yards below the dam of the first spring is another chalybeate spring (II), but only the total solids and ferric oxide were determined in the water. One hundred and twenty-five yards southwest of spring No. 1 is spring No. 8, which is also strongly chalybeate. Only total solids and ferric oxide were determined in the waters of this spring.

ANALYSES OF PANACEA SPRINGS MINERAL
WATER.

Nos. 622, 623, 624.

Name and Formula.	Parts per 1,000,000.		
	No. 1.	No. 2.	No. 8.
Potash (K_2O)	1.20		
Soda (Na_2O)	4.70		
Lime (CaO)	7.00		
Magnesia (MgO)	3.60		
Ferric oxide (Fe_2O_3)	11.50	2.80	1.30
Manganese oxide (Mn_2O_4)	4.00		
Sulphuric oxide (SO_3)	.30		
Chlorine (Cl)	5.50		
Silica (SiO_2)	14.90		
Total solids at 110° C.	107.50	9.50	7.25

HYPOTHETICAL FORM OF COMBINATION.

Name and Formula.	Parts per 1,000,000.	Grains per Gallon.
Sodium chloride ($NaCl$)	10.20	.69
Potassium chloride (KCl)	1.10	.06
Potassium sulphate (K_2SO_4)	.70	.04
Magnesium bicarbonate ($Mg(HCO_3)_2$)	13.10	.76
Calcium bicarbonate ($Ca(HCO_3)_2$)	20.20	1.18
Ferrous bicarbonate ($Fe(HCO_3)_2$)	25.60	1.49
Manganous bicarbonate ($Mn(HCO_3)_2$)	9.60	.52
Silica (SiO_2)	14.90	.87
Total grains per gallon		5.51

SEVEN SPRINGS, WAYNE COUNTY.

The Seven Springs mineral springs are situated in Wayne County near the right bank of the Neuse River, about 9 miles southwest of LaGrange station on the A. and N. C. Railroad. The name applied to these springs originated in the fact that they are seven in number and within a space of about 10 x 15 feet. The volume of water flowing from the several springs varies from 3 gallons per minute from the boldest spring (No. 1) to less than 1 gallon per minute from spring No. 7. The temperature of the water in the several springs, probably varying with the rate of flow of the water, ranges from 16.9° C. to 18° C. The temperature of the air at the time these measurements were taken was 29.9° C.

The location of the springs is only a few yards back of the river bank, on a terrace from 1 to 200 yards wide and just above the high-water mark of severe freshets. One hundred to 150 yards back of the springs the surface rises rapidly to a height of from 60 to 80 feet above the river to a still higher terrace which merges into the general surface of the country. The front of this upper terrace has been cut into



A, NEW PANACEA HOTEL, PANACEA SPRINGS, WARREN COUNTY, N. C.



B, LAKE COVERING FORTY ACRES, PANACEA SPRINGS, WARREN COUNTY, N. C.



A, LAKE AND SPRING-HOUSE, PANACEA SPRINGS, WARREN COUNTY, N. C.



B, SPRING-HOUSE, PANACEA SPRINGS, WARREN COUNTY, N. C.

rugged forms through the eroding action of the small branches and the rains in such a way as to give an exceedingly picturesque appearance to the region. Hotel accommodations have been provided on the upper terrace only a couple of hundred yards from the springs.

ANALYSES OF SEVEN SPRINGS MINERAL WATERS.

Nos. 736, 737, 738, 739, 740, 741, 742.

Name and Formula.	Parts per 1,000,000.						
	Spring No. 1.	Spring No. 2.	Spring No. 3.	Spring No. 4.	Spring No. 5.	Spring No. 6.	Spring No. 7.
Potash (K ₂ O) -----	.6	.8	1.2	1.4	.6	.9	.6
Soda (Na ₂ O) -----	4.7	4.0	6.1	4.2	3.7	4.0	3.7
Lime (CaO) -----	3.9	3.5	2.7	2.4	3.8	3.8	4.0
Magnesia (MgO) -----	1.5	1.7	1.5	2.1	1.6	1.5	1.8
Ferric oxide (Fe ₂ O ₃) -----	5.0	3.7	2.4	4.5	2.0	2.6	6.4
Manganese oxide (Mn ₂ O ₃) -----	trace			trace	trace		
Sulphuric oxide (SO ₂) -----	9.0	9.7	7.7	9.2	9.9	9.4	10.3
Chlorine (Cl) -----	5.4	4.6	7.0	4.8	4.2	4.6	4.2
Phosphoric oxide (P ₂ O ₅) -----	trace	trace	trace	trace	trace	trace	trace
Silica (SiO ₂) -----	14.9	14.4	15.4	14.9	13.7	12.9	16.6
Total solids at 110° C. -----	46.0	50.0	50.0	47.0	40.0	40.0	47.0

HYPOTHETICAL FORM OF COMBINATION.

Name and Formula.	Parts per 1,000,000.						
	Spring No. 1.	Spring No. 2.	Spring No. 3.	Spring No. 4.	Spring No. 5.	Spring No. 6.	Spring No. 7.
Sodium chloride (NaCl) -----	8.9	7.6	11.5	7.9	6.9	7.6	6.9
Potassium sulphate (K ₂ SO ₄) -----	1.1	1.4	2.2	2.6	1.1	1.7	1.1
Calcium sulphate (CaSO ₄) -----	9.5	8.5	6.6	5.8	9.4	9.2	9.8
Calcium phosphate (CaH ₄ (PO ₄) ₃) -----	trace	trace	trace	trace	trace	trace	trace
Magnesium sulphate (MgSO ₄) -----	5.5	5.6	4.6	6.7	5.4	4.8	5.8
Ferrous bicarbonate (Fe(HCO ₃) ₂) -----	11.1	8.1	5.3	9.9	4.4	5.7	14.1
Manganese bicarbonate (Mn(HCO ₃) ₂) -----	trace			trace	trace		
Silica (SiO ₂) -----	14.9	14.4	15.4	14.9	13.7	12.9	16.6

HYPOTHETICAL FORM OF COMBINATION.

Name and Formula.	Grains per Gallon.						
	Spring No. 1.	Spring No. 2.	Spring No. 3.	Spring No. 4.	Spring No. 5.	Spring No. 6.	Spring No. 7.
Sodium chloride (NaCl) -----	.519	.443	.671	.460	.402	.443	.402
Potassium sulphate (K ₂ SO ₄) -----	.064	.082	.128	.152	.064	.099	.064
Calcium sulphate (CaSO ₄) -----	.554	.495	.384	.338	.584	.537	.572
Calcium phosphate (CaH ₄ (PO ₄) ₃) -----	trace	trace	trace	trace	trace	trace	trace
Magnesium sulphate (MgSO ₄) -----	.321	.327	.268	.391	.315	.280	.338
Ferrous bicarbonate (Fe(HCO ₃) ₂) -----	.589	.472	.309	.577	.257	.332	.822
Manganese bicarbonate (Mn(HCO ₃) ₂) -----	trace			trace	trace		
Silica (SiO ₂) -----	.868	.840	.898	.868	.790	.752	.969
Total grains per gallon -----	2.915	2.659	2.658	2.786	2.412	2.443	3.167

DESCRIPTION OF SPRINGS IN THE PIEDMONT PLATEAU.

HEALING SPRINGS, CABARRUS COUNTY.

These springs, two in number, are 17 miles from Lexington, Davidson County. One is a sulphur and the other a chalybeate spring. The chalybeate spring has a flow of $3\frac{1}{2}$ gallons per minute and a temperature of 15.6° C. The water comes out from rocks beside a small branch at the foot of a hill.

The sulphur spring has no smell of hydrogen sulphide and but little sediment. The flow was about one-half gallon per minute and the temperature 16.6° C. Little care was taken of the spring and there were no accommodations for guests. The two springs are about 15 feet apart in the same ledge of rock.

ANALYSES OF HEALING SPRINGS MINERAL WATER.

Nos. 678 and 625.

Name and Formula.	Parts per 1,000,000.	
	Sulphur Spring.	Chalybeate Spring.
Potash (K ₂ O) -----	.6	.3
Soda (Na ₂ O) -----	13.7	11.4
Lime (CaO) -----	51.0	40.5
Magnesia (MgO) -----	10.6	7.9
Ferric oxide (Fe ₂ O ₃) -----	1.1	3.2
Manganese oxide (Mn ₂ O ₄) -----		2.9
Sulphuric oxide (SO ₂) -----	7.0	7.4
Chlorine (Cl) -----	5.6	6.0
Phosphoric oxide (P ₂ O ₅) -----		trace
Silica (SiO ₂) -----	43.9	42.1
Total solids at 110° C. -----	175.0	180.0

HYPOTHETICAL FORM OF COMBINATION.

Name and Formula.	Sulphur Spring.		Chalybeate Spring.	
	Parts per 1,000,000.	Grains per Gallon.	Parts per 1,000,000.	Grains per Gallon.
Sodium chloride (NaCl) -----	9.2	.54	9.8	.57
Sodium sulphate (Na ₂ SO ₄) -----	11.5	.67	13.7	.80
Sodium bicarbonate (NaHCO ₃) -----	10.6	.62		
Potassium sulphate (K ₂ SO ₄) -----	1.1	.06	.5	.03
Magnesium bicarbonate (Mg(HCO ₃) ₂) -----	38.7	2.26	28.8	1.68
Calcium bicarbonate (Ca(HCO ₃) ₂) -----	147.4	8.60	116.8	6.81
Calcium phosphate (CaH ₄ (PO ₄) ₂) -----	trace	trace	trace	trace
Ferrous bicarbonate (Fe(HCO ₃) ₂) -----	2.4	.14	7.1	.41
Manganous bicarbonate (Mn(HCO ₃) ₂) -----			6.6	.39
Silica (SiO ₂) -----	43.9	2.56	42.1	2.46
Total grains per gallon -----		15.45		13.15

STRADER'S SPRING, PELHAM, CASWELL COUNTY.

This spring is owned by G. W. Strader, Pelham, N. C., and is situated about $2\frac{1}{2}$ miles northwest of the town. It comes up into a

stone basin, but is not taken care of now. This has never been a place where health seekers came, but years ago was a place for campers and picnickers. The temperature of the water is 14.8° C., with an air temperature of 32.8° C. The flow of the spring is about one-half gallon per minute. The water has no decided odor or taste, but is slightly milky in appearance. There are no houses near the spring.

ANALYSIS OF STRADER'S SPRING MINERAL WATER.

No. 723.

Name of Formula.	Parts per 1,000,000.
Potash (K_2O)	2.3
Soda (Na_2O)	10.4
Lime (CaO)	23.9
Magnesia (MgO)	9.4
Ferric oxide (Fe_2O_3)	3.8
Sulphuric oxide (SO_3)	3.6
Chlorine (Cl)	2.4
Phosphoric oxide (P_2O_5)	trace
Silica (SiO_2)	42.0
Total solids at 110° C.	136.0

HYPOTHETICAL FORM OF COMBINATION.

Name and Formula.	Parts per 1,000,000.	Grains per Gallon.
Sodium chloride ($NaCl$)	3.9	.23
Sodium sulphate (Na_2SO_4)	2.9	.17
Sodium bicarbonate ($NaHCO_3$)	20.1	1.17
Potassium sulphate (K_2SO_4)	4.2	.25
Magnesium bicarbonate ($Mg(HCO_3)_2$)	34.0	1.98
Calcium phosphate ($CaH_4(PO_4)_3$)	trace	trace
Calcium bicarbonate ($Ca(HCO_3)_2$)	68.8	4.01
Ferrous bicarbonate ($Fe(HCO_3)_2$)	8.5	.49
Silica (SiO_2)	42.0	2.45
Total grains per gallon		10.75

PARKS SPRING, CASWELL COUNTY.

This spring is located 6 miles east of Pelham. The water has quite an extensive use all through the surrounding country and as far as Danville, Va. The temperature of the water is 14.8° C. when the air temperature is 26° C. The flow is about one-half gallon per minute. The water is very cool, clear, and tastes well, leaving a slightly bitter after taste in the mouth. It has no perceptible odor and does not show any escaping gases. The spring comes up beside a small creek into a section of terra-cotta pipe and is kept very well and clean. There are no accommodations for guests.

ANALYSIS OF PARKS SPRING MINERAL WATER.

Name and Formula.	Parts per 1,000,000.
Potash (K_2O)	1.6
Soda (Na_2O)	14.1
Lime (CaO)	38.7
Magnesia (MgO)	4.9
Ferric oxide (Fe_2O_3)	3.3
Manganese oxide (Mn_2O_3)	2.7
Sulphuric oxide (SO_3)	7.6
Chlorine (Cl)	3.6
Phosphoric oxide (P_2O_5)	trace
Silica (SiO_2)	45.4
Total solids at $110^{\circ} C.$	198.0

HYPOTHETICAL FORM OF COMBINATION.

Name and Formula.	Parts per 1,000,000.	Grains per Gallon.
Sodium chloride ($NaCl$)	5.8	.34
Sodium sulphate (Na_2SO_4)	11.3	.65
Sodium bicarbonate ($NaHCO_3$)	16.5	.96
Potassium sulphate (K_2SO_4)	2.9	.17
Magnesium bicarbonate ($Mg(HCO_3)_2$)	17.7	1.01
Calcium phosphate ($CaH_4(PO_4)_2$)	trace	trace
Calcium bicarbonate ($Ca(HCO_3)_2$)	96.9	5.65
Ferrous bicarbonate ($Fe(HCO_3)_2$)	7.3	.43
Manganous bicarbonate ($Mn(HCO_3)_2$)	6.3	.37
Silica (SiO_2)	45.4	2.65
Total grains per gallon		12.23

CATAWBA SPRING, CATAWBA COUNTY.

This spring is located at Catawba Springs, 8 miles from Hickory, the nearest station on the Southern Railway. The spring has been developed and accommodations provided for guests by the Catawba Springs Hotel Company. The location is delightful and the place is patronized as a summer resort.

ANALYSIS OF CATAWBA SPRING MINERAL WATER.

No. 682.

Name and Formula.	Parts per 1,000,000.
Potash (K_2O)	3.2
Soda (Na_2O)	34.9
Lime (CaO)	3.9
Magnesia (MgO)	1.9
Ferric oxide (Fe_2O_3)	1.1
Sulphuric oxide (SO_3)	3.5
Phosphoric oxide (P_2O_5)	trace
Chlorine (Cl)	10.6
Silica (SiO_2)	20.5
Total solids at $110^{\circ} C.$	128.0



A, VIEW AT MOUNT VERNON SPRINGS, N. C.



B, HOTEL AT MOUNT VERNON SPRINGS, N. C.

HYPOTHETICAL FORM OF COMBINATION.

Name and Formula.	Parts per 1,000,000.	Grains per Gallon.
Sodium chloride (NaCl) -----	17.5	1.03
Sodium sulphate (Na ₂ SO ₄) -----	1.8	.10
Sodium bicarbonate (NaHCO ₃) -----	67.8	3.95
Potassium sulphate (K ₂ SO ₄) -----	5.9	.34
Magnesium bicarbonate (Mg(HCO ₃) ₂) -----	6.9	.40
Calcium bicarbonate (Ca(HCO ₃) ₂) -----	11.3	.65
Ferrous bicarbonate (Fe(HCO ₃) ₂) -----	2.4	.14
Silica (SiO ₂) -----	20.5	1.19
Total grains per gallon -----		7.80

MOUNT VERNON SPRINGS, ORE HILL, CHATHAM COUNTY.

These springs are situated about $1\frac{1}{4}$ miles from the Ore Hill station on the Cape Fear and Yadkin Railroad. There are ample hotel accommodations for guests and the grounds are improved (Pls. IX, A and B). The springs are two in number and about 3 feet apart and 3 and 4 feet deep down to solid rock. They are carefully enclosed and well kept. The flow of the springs is 1 and $1\frac{1}{2}$ gallons, respectively.

ANALYSES OF MOUNT VERNON SPRINGS MINERAL
No. 605. WATER.

Name and Formula.	Parts per 1,000,000.	
	Spring No. 1.	Spring No. 2.
Potash (K ₂ O) -----	2.0	-----
Soda (Na ₂ O) -----	15.6	-----
Lime (CaO) -----	160.5	-----
Magnesia (MgO) -----	6.6	-----
Ferric oxide (Fe ₂ O ₃) -----	.8	-----
Sulphuric oxide (SO ₃) -----	84.3	-----
Chlorine (Cl) -----	16.0	16.0
Phosphoric oxide (P ₂ O ₅) -----	trace	-----
Silica (SiO ₂) -----	25.4	-----
Total solids at 110° C. -----	485.0	470.

HYPOTHETICAL FORM OF COMBINATION.

Name and Formula.	Parts per 1,000,000.	Grains per Gallon.
Sodium chloride (NaCl) -----	30.	1.75
Sodium sulphate (Na ₂ SO ₄) -----	4.6	.27
Potassium sulphate (K ₂ SO ₄) -----	.6	.03
Magnesium bicarbonate (Mg(HCO ₃) ₂) -----	24.0	1.40
Calcium sulphate (CaSO ₄) -----	138.2	8.06
Calcium phosphate (CaH ₄ (PO ₄) ₂) -----	trace	trace
Calcium bicarbonate (Ca(HCO ₃) ₂) -----	299.0	17.45
Ferrous bicarbonate (Fe(HCO ₃) ₂) -----	1.8	.10
Silica (SiO ₂) -----	25.4	1.48
Total grains per gallon -----		30.54

There was no deposit observed and the water is clear and without odor. The sample was taken July 5, 1895. The temperature ranges about 15.5° C. The water is for sale in 5 and 10-gallon carboys and in 1-pint and half-gallon bottles.

PATTERSON SPRING, NEAR SHELBY, CLEVELAND COUNTY.

This spring is 4 miles south of Shelby and is well kept. It flows one-third of a gallon per minute and the temperature observed in July, 1896, was 20° C. The water gives off an odor of hydrogen sulphide.

ANALYSIS OF PATTERSON SPRING MINERAL WATER.
No. 654.

Name and Formula.	Parts per 1,000,000.
Potash (K_2O)	2.2
Soda (Na_2O)	10.4
Lime (CaO)	28.3
Magnesia (MgO)	4.7
Ferrie oxide (Fe_2O_3)	.6
Sulphuric oxide (SO_3)	5.9
Chlorine (Cl)	11.2
Silica (SiO_2)	29.1
Total solids at 110° C.	132.0

HYPOTHETICAL FORM OF COMBINATION.

Name and Formula.	Parts per 1,000,000.	Grains per Gallon.
Sodium chloride ($NaCl$)	19.0	1.10
Sodium sulphate (Na_2SO_4)	1.6	.09
Potassium sulphate (K_2SO_4)	3.9	.22
Magnesium bicarbonate ($Mg(HCO_3)_2$)	17.2	1.00
Calcium sulphate ($CaSO_4$)	5.6	.32
Calcium bicarbonate ($Ca(HCO_3)_2$)	75.4	4.39
Ferrous bicarbonate ($Fe(HCO_3)_2$)	1.3	.07
Silica (SiO_2)	29.1	1.69
Total grains per gallon		8.88

M'BRAYER SPRING, CLEVELAND COUNTY.

This spring is about 4 miles northwest of Shelby and is beside the same branch on which the Lithia Spring is located. The spring has quite an extensive reputation and is said to be the first one discovered in this county and has been known for many years. The water is said to be equal to that of Cleveland or Patterson's springs. The spring flows out of the side of the hill and into a stone basin.

There was formerly a hotel here, but for a good many years past it has been allowed to fall into decay and is nearly uninhabitable. The temperature of the water is 16.4° C. and the flow is about $1\frac{1}{2}$ gallons per minute. The odor and taste of sulphur is very perceptible.

ANALYSIS OF McBRAYER SPRING MINERAL
WATER.

No. 718.

Name and Formula.	Parts per 1,000,000.
Potaash (K_2O)	3.5
Soda (Na_2O)	15.0
Lime (CaO)	20.7
Magnesia (MgO)	4.5
Ferric oxide (Fe_2O_3)	.1
Sulphureted hydrogen (H_2S)	.2
Sulphuric oxide (SO_3)	3.0
Phosphoric oxide (P_2O_5)	trace
Chlorine (Cl)	6.0
Silica (SiO_2)	24.3
Total solids at $110^{\circ} C.$	96.0

HYPOTHETICAL FORM OF COMBINATION.

Name and Formula.	Parts per 1,000,000.	Grains per Gallon.
Sodium chloride ($NaCl$)	9.7	.58
Sodium bicarbonate ($NaHCO_3$)	26.8	1.56
Potassium sulphate (K_2SO_4)	6.5	.38
Magnesium bicarbonate ($Mg(HCO_3)_2$)	16.3	.95
Calcium phosphate ($CaH_2(PO_4)_2$)	trace	trace
Calcium bicarbonate ($Ca(HCO_3)_2$)	59.5	3.47
Ferrous bicarbonate ($Fe(HCO_3)_2$)	.2	.01
Sulphureted hydrogen (H_2S)	.2	.01
Silica (SiO_2)	24.3	1.42
Total grains per gallon		8.38

CLEVELAND SULPHUR SPRINGS, CLEVELAND COUNTY.

These springs, 3 in number, are close together and are located 2 miles southeast of Shelby, Cleveland County. The more prominent and better known one is the White Sulphur Spring, which is well kept and has a natural rock bottom. The flow of the spring is 2 gallons per minute and its temperature in 1896 was $18^{\circ} C.$ The water has a decided odor of hydrogen sulphide.

The second spring, known as Red Sulphur Spring, has a flow of 1 gallon per minute and a temperature of $16.8^{\circ} C.$ (summer of 1896). It has a decided odor and taste of hydrogen sulphide.

The third spring, known as the Iron Spring, has a flow considerably less than 1 gallon per minute and a temperature but little below that of the atmosphere. The water is strongly chalybeate, as is seen from the analysis below.

There are no special arrangements for visitors at these springs and guests find hotel accommodations at Shelby. These springs have been known and used for over half a century, but only within recent years

have the waters been brought prominently before the public. In the following table there is given the analysis of each of these springs:

ANALYSES OF CLEVELAND SULPHUR SPRINGS MINERAL WATER.

Nos. 655, 638 and 635.

	Parts per 1,000,000.		
	White Sulphur Spring.	Red Sulphur Spring.	Iron Spring.
Potash (K_2O)	2.6	3.9	3.5
Soda (Na_2O)	11.6	11.5	6.2
Lime (CaO)	31.1	21.6	8.6
Magnesia (MgO)	7.3	4.5	4.5
Ferric oxide (Fe_2O_3)	1.5	1.2	14.4
Manganese oxide (Mn_2O_4)	trace		3.1
Sulphuric oxide (SO_2)	4.9	4.6	.4
Phosphoric oxide (P_2O_5)		trace	trace
Chlorine (Cl)	13.2	5.0	7.0
Silica (SiO_2)	31.0	25.3	29.7
Total solids at 110^0 C.	135.0	113.0	102.0

HYPOTHETICAL FORM OF COMBINATION.

Nos. 655, 638 and 635.

Name and Formula.	White Sulphur Spring.		Red Sulphur Spring.		Iron Spring.	
	Parts per 1,000,000.	Grains per Gallon.	Parts per 1,000,000.	Grains per Gallon.	Parts per 1,000,000.	Grains per Gallon.
Sodium sulphate (Na_2SO_4)			2.3	.13		
Sodium chloride ($NaCl$)	22.4	1.31	8.2	.48	11.5	.67
Sodium bicarbonate ($NaHCO_3$)			6.5	.96		
Potassium sulphate (K_2SO_4)	4.7	.27	7.2	.42	6.5	.38
Magnesium bicarbonate ($Mg(HCO_3)_2$)	26.7	1.56	16.4	.96	16.4	.96
Calcium sulphate ($CaSO_4$)	4.9	.28				
Calcium phosphate ($CaH_2(PO_4)_2$)			trace	trace		
Calcium bicarbonate ($Ca(HCO_3)_2$)	84.4	4.92	67.2	3.91	24.9	1.45
Ferrous bicarbonate ($Fe(HCO_3)_2$)	3.3	.19	2.6	.15	31.8	1.85
Manganous bicarbonate ($Mn(HCO_3)_2$)	trace	trace			7.3	.44
Silica (SiO_2)	31.0	1.81	25.3	1.47	27.9	1.63
Total grains per gallon		10.34		8.48		7.38

CLEVELAND MILLS SULPHUR SPRING, CLEVELAND COUNTY.

About 12 miles south of Shelby, between the two Cleveland cotton mills, on the bank of Maple Creek near its confluence with the first Broad River, there is a small sulphur spring known as "The Sulphur Spring." It is largely used in the neighborhood as a tonic water and has the reputation of some cures. The spring is totally unimproved, but is kept clean and is much visited by picnic parties. There are no accommodations for guests nearer than Cleveland Mills, and the only house near it is a mill house about 100 yards up the creek. The spring water rises into a wooden box about 1 foot square from a low place

about 10 feet from the creek bank, and flows at the rate of about 1 gallon per minute and has a temperature of 14.8° C. (58.4° F.). The water has a slight smell and taste of hydrogen sulphide.

ANALYSIS OF COTTON MILLS SULPHUR SPRING
MINERAL WATER.

No. 726.

Name and Formula.	Parts per 1,000,000.
Potash (K ₂ O) -----	3.6
Soda (Na ₂ O) -----	8.2
Lime (CaO) -----	33.2
Magnesium (MgO) -----	4.8
Ferric oxide (Fe ₂ O ₃) -----	.7
Sulphuric oxide (SO ₂) -----	7.0
Chlorine (Cl) -----	3.2
Sulphureted hydrogen (H ₂ S) -----	.3
Silica (SiO ₂) -----	31.0
Total solids at 110° C. -----	128.0

HYPOTHETICAL FORM OF COMBINATION.

Name and Formula.	Parts per 1,000,000.	Grains per Gallon.
Sodium chloride (NaCl) -----	5.2	.30
Sodium sulphate (Na ₂ SO ₄) -----	6.8	.40
Sodium bicarbonate (NaHCO ₃) -----	5.3	.31
Potassium sulphate (K ₂ SO ₄) -----	6.6	.38
Magnesium bicarbonate (Mg(HCO ₃) ₂) -----	19.6	1.14
Calcium phosphate (CaH ₄ (PO ₄) ₃) -----	trace	trace
Calcium bicarbonate (Ca(HCO ₃) ₂) -----	95.6	5.58
Ferrous bicarbonate (Fe(HCO ₃) ₂) -----	1.6	.09
Sulphureted hydrogen (H ₂ S) -----	.3	.02
Silica (SiO ₂) -----	31.0	1.80
Total grains per gallon -----		10.02

SHELBY LITHIA SPRING, CLEVELAND COUNTY.

This spring is 3 miles north of Shelby. The water is brought in iron pipes to a fountain on the courthouse square, where it is for sale.

ANALYSIS OF SHELBY LITHIA SPRING MINERAL WATER.

No. 684.

Name and Formula.	Parts per 1,000,000.
Potash (K ₂ O) -----	2.7
Soda (Na ₂ O) -----	8.1
Lime (CaO) -----	24.5
Magnesia (MgO) -----	4.8
Ferric oxide (Fe ₂ O ₃) -----	.4
Manganese oxide (Mn ₂ O ₃) -----	1.3
Sulphuric oxide (SO ₂) -----	5.7
Chlorine (Cl) -----	1.8
Phosphoric oxide (P ₂ O ₅) -----	trace
Silica (SiO ₂) -----	25.1
Total solids at 110° C. -----	123.0

HYPOTHETICAL FORM OF COMBINATION.

Name and Formula.	Parts per 1,000,000.	Grains per Gallon.
Sodium chloride (NaCl)-----	2.9	.17
Sodium sulphate (Na ₂ SO ₄)-----	6.0	.35
Sodium bicarbonate (NaHCO ₃)-----	7.9	.46
Potassium sulphate (K ₂ SO ₄)-----	5.0	.29
Magnesium bicarbonate (Mg(HCO ₃) ₂)-----	17.5	1.02
Calcium bicarbonate (Ca(HCO ₃) ₂)-----	7.8	4.13
Ferrous bicarbonate (Fe(HCO ₃) ₂)-----	.8	.05
Manganous bicarbonate (Mn(HCO ₃) ₂)-----	2.8	.16
Silica (SiO ₂)-----	25.1	1.47
Total grains per gallon-----		8.10

The flow is about 1 gallon per minute and the temperature 15.4° C. The water smells strongly of hydrogen sulphide. The sample was drawn from the spring late in the summer of 1897.

MINERAL SPRINGS AT WINSTON-SALEM, FORSYTH COUNTY.

The Old Salem Spring.—This spring is situated on the outskirts of the town of Salem, about one-half mile southwest from the center of the town and quite near to the railway. Its water has been used for a number of years and it has quite a local reputation. The spring is neatly enclosed and kept clean. It has a faint odor of hydrogen sulphide and is to be classed among the weak sulphur springs. It is also strongly impregnated with iron and there is an iron deposit in the outflow. The spring is not an old one.

South Side Park Spring.—This is located about 1 mile south of Winston-Salem in one of the city parks. The spring is enclosed in a terra-cotta pipe which is sunk around it. There are no other improvements. The flow is moderate and the temperature is about 15.5° C.

HYPOTHETICAL FORM OF COMBINATION.

Name and Formula.	Old Salem Spring.		South Side Park Spring.	
	Parts per 1,000,000.	Grains per Gallon.	Parts per 1,000,000.	Grains per Gallon.
Sodium chloride (NaCl)-----	7.8	.45	2.6	.15
Potassium chloride (KCl)-----	5.6	.33	1.1	.06
Potassium sulphate (K ₂ SO ₄)-----	.5	.03	.9	.05
Magnesium bicarbonate (Mg(HCO ₃) ₂)-----	15.3	.89	5.7	.33
Calcium bicarbonate (Ca(HCO ₃) ₂)-----	25.5	1.49	9.0	.52
Calcium phosphate (CaH(PO ₄) ₂)-----			trace	trace
Ferrous bicarbonate (Fe(HCO ₃) ₂)-----	98.8	5.76	1.3	.08
Hydrogen sulphide (H ₂ S)-----	weak	weak		
Silica (SiO ₂)-----	12.8	.75	15.6	.91
Total grains per gallon-----		9.70		2.10

MARIENBAD SPRINGS, FORSYTH COUNTY.

These springs are situated 2 miles from Winston in a northwesterly direction on the slope of a hill. They are 14 in number and within a few feet of each other. The side of the hill has been cut back and the springs enclosed in large terra-cotta pipes sunk in around them. Most of them are clear, without odor and deposit. One has a slight odor of hydrogen sulphide and one forms a deposit of ferric hydroxide. There are no sources of contamination near the springs and the water is remarkably pure. There are abundant hotel accommodations. The water is delivered also to customers in Winston. The samples were taken in July, 1895. A full analysis is given of spring No. 5 and partial analyses of the remaining springs.

ANALYSIS OF MARIENBAD SPRING, No. 5.

Name and Formula.	Parts per 1,000,000.
Potash (K_2O) -----	.6
Soda (Na_2O) -----	1.4
Lime (CaO) -----	4.4
Magnesia (MgO) -----	1.9
Ferric oxide (Fe_2O_3) -----	.7
Sulphuric oxide (SO_2) -----	.2
Phosphoric oxide (P_2O_5) -----	trace
Silica (SiO_2) -----	19.7
Total solids at $110^\circ C.$ --	47.5

HYPOTHETICAL FORM OF COMBINATION.

Name and Formula.	Parts per 1,000,000.	Grains per Gallon.
Sodium chloride ($NaCl$) -----	2.9	.17
Potassium chloride (KCl) -----	.5	.03
Potassium sulphate (K_2SO_4) -----	.5	.03
Magnesium bicarbonate ($Mg(HCO_3)_2$) -----	5.2	.30
Calcium phosphate ($CaH_4(PO_4)_2$) -----	trace	trace
Calcium bicarbonate ($Ca(HCO_3)_2$) -----	12.5	.73
Ferrous bicarbonate ($Fe(HCO_3)_2$) -----	1.6	.09
Silica (SiO_2) -----	19.7	1.15
Total grains per gallon -----		2.50

TOTAL SOLIDS IN MARIENBAD SPRINGS, NEAR
WINSTON, FORSYTH COUNTY.

Nos. 608, 620.

Spring.	Parts per 1,000,000.	Spring.	Parts per 1,000,000.
No. 1 -----	40.	No. 8 -----	50.
No. 2 -----	50.	No. 9 -----	75.
No. 3 -----	47.5	No. 10 -----	50.
No. 4 -----	45.0	No. 11 -----	42.5
No. 5 -----	47.5	No. 12 -----	40.
No. 6 -----	37.5	No. 13 -----	40.
No. 7 -----	45.	No. 14 -----	40.

ALL HEALING SPRINGS, GASTON COUNTY.

These springs are between 4 and 5 miles from Bessemer City. The springs are four in number, the one called "All Healing" being the one most used and was the only one sampled. The other springs are known as "Iron," "Sulphur" and "Union." All are covered in with brickwork and the outflow is through pipes. The flow of all is slight. The water of the All Healing Spring is odorless, but has a slight taste. The summer temperature is 15.6° C. (60° F.).

ANALYSIS OF ALL HEALING SPRING MINERAL WATER.

No. 681.

Name and Formula.	Parts per 1,000,000.
Potash (K_2O)	.6
Soda (Na_2O)	2.4
Lime (CaO)	3.5
Magnesia (MgO)	2.0
Ferric oxide (Fe_2O_3)	.4
Sulphuric oxide (SO_3)	4.9
Chlorine (Cl)	2.8
Phosphoric oxide (P_2O_5)	trace
Silica (SiO_2)	8.9
Total solids at 110° C.	57.0

HYPOTHETICAL FORM OF COMBINATION.

Name and Formula.	Parts per 1,000,000.	Grains per Gallon.
Sodium chloride ($NaCl$)	4.6	.27
Potassium sulphate (K_2SO_4)	1.1	.06
Magnesium bicarbonate ($Mg(HCO_3)_2$)	7.3	.43
Calcium bicarbonate ($Ca(HCO_3)_2$)	10.1	.58
Ferrous bicarbonate ($Fe(HCO_3)_2$)	.8	.05
Silica (SiO_2)	8.9	.52
Total grains per gallon		1.91

BUCKHORN LITHIA SPRING, GRANVILLE COUNTY.

More water is shipped from the Buckhorn Lithia Spring at the present time than from any other spring in North Carolina and it is very rapidly acquiring favor, and wherever used it has been very highly commended. It is about 10 miles north of Oxford and 1 mile from Bullock, a small station on the Southern Railway. The spring is located on the side of a hill that rises gradually to a height of about 40 feet above the stream bed. The water flows from crevices in the solid rock and was discovered in 1904 by two sons of Mr. B. T. Hicks, on whose land the spring was located. The boys in drinking the water noticed its peculiar character, and speaking of this, it soon attracted



A, COUNTRY HOME FOUR HUNDRED YARDS FROM BUCKHORN LITHIA SPRINGS, WHERE MANY VISITORS TO THE SPRINGS ARE ENTERTAINED.



B, BUCKHORN LITHIA SPRING AND BOTTLING PLANT.

the attention of others. In September, 1905, it was purchased by a stock company and early in 1906 the company began to ship the water. There are no hotel accommodations for guests at the springs, but there was a large country house that has been arranged for the accommodation of guests who wish to stop at the springs (see Pls. X, A and B). The flow of the spring is approximately $11\frac{1}{2}$ gallons per minute.

Upon analysis the water was found to contain a decidedly noticeable percentage of lithia. A complete analysis by Mr. Donald L. Liddell, of Johns Hopkins University, gave the following results, the report being made in the hypothetical form of combination of the constituents:

ANALYSIS* OF BUCKHORN LITHIA MINERAL WATER.

Name and Formula.	Grains per Gallon.
Sodium chloride (NaCl) -----	.61
Sodium sulphate (Na ₂ SO ₄) -----	.34
Sodium bicarbonate (NaHCO ₃) -----	.38
Potassium chloride (KCl) -----	.06
Lithium bicarbonate (LiHCO ₃) -----	4.71
Magnesium bicarbonate (Mg(HCO ₃) ₂) -----	2.57
Calcium bicarbonate (Ca(HCO ₃) ₂) -----	9.7
Iron oxide (Fe ₂ O ₃) -----	.18
Aluminum oxide (Al ₂ O ₃) -----	
Silica (SiO ₂) -----	1.6
Total grains per gallon -----	20.15

*Donald L. Liddell, Analyst.

CRESWELL SPRING, IREDELL COUNTY.

This spring is 2 miles in a southerly direction from Mooresville. Its waters have been used for medicinal purposes since 1794. At one time it was much visited by families from Charlotte and other neighboring towns, who built a number of cottages near by. It is still used by persons in the neighborhood.

ANALYSIS OF CRESWELL SPRING MINERAL WATER.

No. 631.

Name and Formula.	Parts per 1,000,000.
Potash (K ₂ O) -----	4.
Soda (Na ₂ O) -----	14.9
Lime (CaO) -----	54.7
Magnesia (MgO) -----	3.7
Ferric oxide (Fe ₂ O ₃) -----	1.8
Sulphuric oxide (SO ₃) -----	26.9
Chlorine (Cl) -----	4.0
Phosphoric oxide (P ₂ O ₅) -----	trace
Silica (SiO ₂) -----	91.4
Total solids at 110° C. -----	315.

HYPOTHETICAL FORM OF COMBINATION.

Name and Formula.	Parts per 1,000,000.	Grains per Gallon.
Sodium chloride (NaCl) -----	7.5	.44
Sodium sulphate (Na ₂ SO ₄) -----	26.1	1.52
Potassium sulphate (K ₂ SO ₄) -----	7.4	.43
Magnesium bicarbonate (Mg (HCO ₃) ₂) -----	13.5	.79
Calcium bicarbonate (Ca (HCO ₃) ₂) -----	140.8	8.21
Calcium sulphate (CaSO ₄) -----	20.7	1.21
Ferrous bicarbonate (Fe (HCO ₃) ₂) -----	4.0	.23
Silica (SiO ₂) -----	91.4	5.33
Total grains per gallon -----		18.16

The spring is neatly enclosed and the water is clear and odorless. The flow is one-half gallon per minute and the temperature at the time of taking the sample (July, 1895) was 15.5° C.

BARIUM SPRINGS, IREDELL COUNTY.

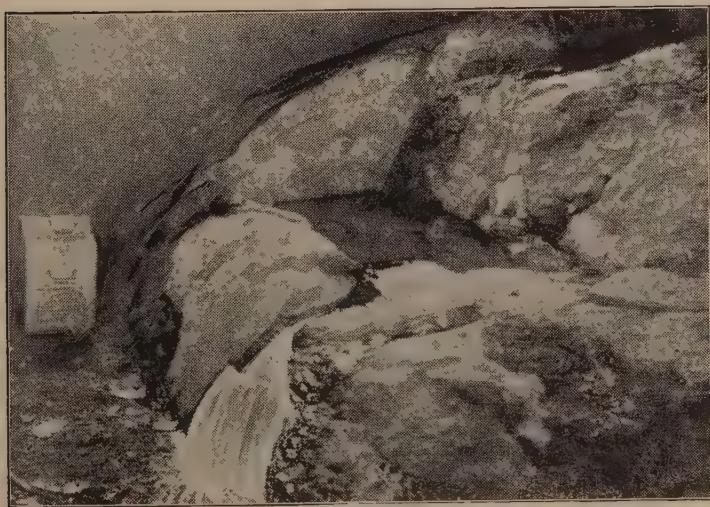
The celebrated Barium Springs are located a short distance from Barium Springs station on the Southern Railway, 5 miles south of Statesville and about one-half mile west of the Presbyterian Orphanage. There are a series of 9 springs in the group, known as follows:

1. Barium Rock Spring.
2. Potash White Sulphur Spring.
3. Alkaline Calcic Spring.
4. Sulpho Calcic Spring.
5. Saline Chalybeate Spring.
6. Chalybeate Spring.
7. Magnesia.
8. Saline.
9. Chalybeate.

Of these springs the Barium Rock Spring (Pl. XI, A) is the one that has called special attention to the group and is the one that is used the most. It is also the only water that is being bottled and shipped, and a considerable business has been built up in the shipment of this water. This is another one of the springs of the State whose discovery is attributed to the Indians, who are supposed to have realized its medicinal value and to have made pilgrimages to it. It has been used locally for a great many years, and recently the property has been improved and a hotel of 40 rooms erected for the accommodation of guests, and bottling works established. The Barium Rock Spring issues from the side of a rock, as shown in Plate XI, B, and has a flow of about 1½ gallons per minute. The basin for holding the water is cut into the rock and has a capacity of about 375 gallons. The temperature of the spring



A, BARIUM ROCK SPRING, BARIUM SPRINGS, N. C.



B, CELEBRATED ROCK SPRING, AT BARIUM SPRINGS, N. C.

is approximately that of the atmosphere. A complete analysis has been made of the Barium Rock Spring water and a qualitative analysis of a number of the others, the results of which are given below:

ANALYSIS OF BARIUM SPRING MINERAL WATER.

No. 632.

Name and Formula.	Parts per 1,000,000.
Potash (K_2O)	3.8
Soda (Na_2O)	13.4
Lime (CaO)	39.8
Magnesia (MgO)	5.2
Ferric oxide (Fe_2O_3)	1.4
Sulphuric oxide (SO_3)	8.8
Chlorine (Cl)	5.5
Phosphoric oxide (P_2O_5)	trace
Silica (SiO_2)	31.8
Total solids at $110^\circ C.$	193.5

HYPOTHETICAL FORM OF COMBINATION.

No. 632.

Name and Formula.	Parts per 1,000,000.	Grains per Gallon.
Sodium chloride ($NaCl$)	10.3	.60
Sodium sulphate (Na_2SO_4)	9.9	.58
Sodium bicarbonate ($NaHCO_3$)	10.0	.58
Potassium sulphate (K_2SO_4)	7.0	.41
Magnesium bicarbonate ($Mg(HCO_3)_2$)	15.3	.89
Calcium phosphate ($CaH_4(PO_4)_3$)	trace	trace
Calcium bicarbonate ($Ca(HCO_3)_2$)	115.1	6.71
Ferrous bicarbonate ($Fe(HCO_3)_2$)	3.1	.18
Silica (SiO_2)	31.8	1.85
Total grains per gallon		11.80

The Chalybeate Spring was tested by W. A. Withers, of the North Carolina Department of Agriculture, and gave: Total solids, 7.2 grains per gallon. It showed the presence of: Soda (Na_2O); potash (K_2O); magnesia (MgO); lime (CaO); iron oxide (Fe_2O_3); chlorine (Cl); carbon dioxide (CO_2).

White Sulphur Spring was also tested by Mr. W. A. Withers, of the State Department of Agriculture, and gave: Total solids, 10.5 grains per gallon, and showed the presence of: Soda (Na_2O); potash (K_2O); magnesia (MgO); lime (CaO); iron oxide (Fe_2O_3); chlorine (Cl); sulphuric oxide (SO_3), and carbonic oxide (CO_2).

The Red Sulphur Spring, tested by Mr. W. A. Withers, gave: Total solids, 10.4 grains per gallon, and showed the presence of: Soda (Na_2O); potash (K_2O); magnesia (MgO), lime (CaO); iron oxide (Fe_2O_3); chlorine (Cl); sulphuric oxide (SO_3); carbonic oxide (CO_2).

EUPEPTIC SPRINGS, IREDELL COUNTY.

These springs (of which there are several) are situated 15 miles north of Statesville. They were at one time used to a considerable extent locally for medicinal purposes, but they are now little used and unimproved.

ANALYSIS OF EUPEPTIC SPRING MINERAL WATER.

No. 633.

Name and Formula.	Parts per 1,000,000.
Potash (K_2O)-----	1.5
Soda (Na_2O)-----	11.2
Lime (CaO)-----	24.4
Magnesia (MgO)-----	5.4
Ferric oxide (Fe_2O_3)-----	.8
Sulphuric oxide (SO_2)-----	15.5
Chlorine (Cl)-----	5.0
Phosphoric oxide (P_2O_5)-----	trace
Silica (SiO_2)-----	24.8
Total solids at $110^{\circ} C$.-----	122.5

HYPOTHETICAL FORM OF COMBINATION.

Name and Formula.	Parts per 1,000,000.	Grains per Gallon.
Sodium chloride ($NaCl$)-----	9.4	.55
Sodium sulphate (Na_2SO_4)-----	12.2	.71
Potassium sulphate (K_2SO_4)-----	2.7	.16
Magnesium bicarbonate ($Mg(HCO_3)_2$)-----	19.7	1.15
Calcium sulphate (Ca_2SO_4)-----	15.2	.88
Calcium phosphate ($CaH_4(PO_4)_2$)-----		trace
Calcium bicarbonate ($Ca(HCO_3)_2$)-----	52.4	3.06
Ferrous bicarbonate ($Fe(HCO_3)_2$)-----	1.7	.10
Silica (SiO_2)-----	24.8	1.45
Total grains per gallon-----		8.06

LINCOLN LITHIA SPRING, LINCOLN COUNTY.

This spring is located $11\frac{1}{2}$ miles from the town of Lincolnton, Lincoln County. The lithia spring is located about the center of a tract of 225 acres of land. There is a hotel situated very close to the spring known as Lithia Inn, which has accommodations for 60 guests. As a result of the popularity of this mineral water and its location in the heart of the Piedmont section, a club known as the Lincoln Lithia Club has recently been organized which has purchased the grounds, hotel, spring and bottling works of the old company and has been incorporated. Its object is to provide a country estate and promote and cultivate social intercourse, games and physical exercises amongst its members. It will have all the equipment and be governed in practically the same way as the various country clubs scattered throughout the

State. Although this makes the spring and property come under the regulations of a club, the bottling works will be continued and the water shipped as formerly.

The flow of the spring is approximately 1 gallon per minute and the temperature is 60° F. A chemical analysis reported by the company gave the following results, the constituents being given in a hypothetical form of combination:

ANALYSIS LINCOLN LITHIA SPRING MINERAL WATER—
HYPOTHETICAL FORM OF COMBINATION.

Name and Formula.	Parts per 1,000,000.
Potassium sulphate (K_2SO_4)	16.21
Sodium chloride ($NaCl$)	14.01
Sodium bicarbonate ($NaHCO_3$)	2.58
Sodium phosphate	trace
Lithium bicarbonate ($LiHCO_3$)	33.6
Magnesium bicarbonate ($Mg(HCO_3)_2$)	8.15
Calcium bicarbonate ($Ca(HCO_3)_2$)	76.36
Calcium sulphate ($CaSO_4$)	12.71
Iron bicarbonate ($Fe(HCO_3)_2$)	2.67
Alumina (Al_2O_3)	trace
Silica (SiO_2)	7.8

MIDA MINERAL SPRING, MECKLENBURG COUNTY.

The Mida Mineral Spring is located in the historic county of Mecklenburg 10 miles northwest of Charlotte. It is one of the springs recently discovered, but since that time it has become well known and is now being put on the market by the Sample Mineral Water Company, of Charlotte. There are no hotel accommodations for guests, although more or less of the water is used locally. It is purely a ship-

ANALYSIS OF THE MIDA SPRING MINERAL WATER—
HYPOTHETICAL FORM OF COMBINATION.

Name and Formula.	Grains per Gallon.
Sodium chloride ($NaCl$)	.209
Sodium sulphate (Na_2SO_4)	.190
Sodium bicarbonate ($NaHCO_3$)	1.170
Sodium nitrate ($NaNO_3$)	.320
Potassium Sulphate (K_2SO_4)	.052
Calcium bicarbonate ($Ca(HCO_3)_2$)	4.135
Calcium phosphate ($CaH_4(PO_4)_2$)	.034
Magnesium bicarbonate ($Mg(HCO_3)_2$)	1.955
Lithium bicarbonate ($LiHCO_3$)	.005
Iron bicarbonate ($Fe(HCO_3)_2$)	.015
Aluminum hydroxide ($Al(OH)_3$)	.005
Manganese bicarbonate ($Mn(HCO_3)_2$)	trace
Barium bicarbonate ($Ba(HCO_3)_2$)	trace
Zinc bicarbonate ($Zn(HCO_3)_2$)	trace
Silica (SiO_2)	3.426
Total grains per gallon	11.525

ping business. The flow of the spring is about 2 gallons per minute and the temperature 60° F. An analysis of this water was made by Prof. Robert C. Price and the results, which were reported in a hypothetical form of combination, are given on page 113.

MONTGOMERY SULPHUR SPRING, MONTGOMERY COUNTY.

This spring is situated 3 miles south of Candor. It has a very small flow—only 1 gallon in every ten minutes—and the temperature is but little above that of the atmosphere. There is an odor of hydrogen sulphide. The water is strongly alkaline and the spring uncared for.

ANALYSIS OF MONTGOMERY SULPHUR SPRING MINERAL WATER.

No. 669.

Name and Formula.	Parts per 1,000,000.
Potash (K ₂ O)-----	8.5
Soda (Na ₂ O)-----	82.5
Lime (CaO)-----	3.9
Magnesia (MgO)-----	.8
Ferric oxide (Fe ₂ O ₃)-----	1.7
Manganese oxide (Mn ₂ O ₄)-----	1.9
Sulphuric oxide (SO ₂)-----	18.2
Chlorine (Cl)-----	18.2
Phosphoric oxide (P ₂ O ₅)-----	trace
Silica (SiO ₂)-----	14.8
Total solids at 110° C.-----	218.0

HYPOTHETICAL FORM OF COMBINATION.

Name and Formula.	Parts per 1,000,000.	Grains per Gallon.
Sodium chloride (NaCl)-----	30.0	.59
Sodium sulphate (Na ₂ SO ₄)-----	.7	.62
Sodium bicarbonate (NaHCO ₃)-----	7.5	10.35
Potassium sulphate (K ₂ SO ₄)-----	5.7	.92
Magnesium bicarbonate (Mg(HCO ₃) ₂)-----	2.9	.17
Calcium phosphate (CaH ₄ (PO ₄) ₂)-----		trace
Calcium bicarbonate (Ca(HCO ₃) ₂)-----	1.3	.65
Ferrous bicarbonate (Fe(HCO ₃) ₂)-----	3.8	.22
Manganous bicarbonate (Mn(HCO ₃) ₂)-----	4.2	.25
Silica (SiO ₂)-----	4.8	.86
Total grains per gallon-----		14.63

JACKSON SPRINGS, MOORE COUNTY.

These springs are located at Jackson Springs, a station on the Ashboro and Aberdeen Railroad in the southwestern corner of Moore County, a short distance from the Montgomery line and 11 miles from the famous resort, Pinehurst, N. C. The spring has been known for a great many years and its reputation continued to grow until, in 1890,

there was sufficient demand for the accommodation of people visiting the springs to warrant the erection of a small hotel for their accommodation, and it was filled to overflowing the first season. The hotel accommodations have been increased constantly since that time until now there is a three-story building with 64 sleeping rooms (see Plate XII, A), which is equipped with all modern conveniences, such as hot and cold water, steam heat and electric lights. Surrounding the hotel is a park containing 800 acres of rolling land, a large part of which is covered with long-leaf pine, hickory and oak. A lake (Pl. XII, B) has also been built in the park which offers splendid fishing, boating and bathing. It has been stocked with black bass. Although the medicinal value of the Barium Spring waters is well known and a great deal of the water is shipped for this purpose, the management have not attempted to make this simply a health resort, but, on the other hand, have combined all those features of a resort that make it attractive to tourists and the pleasure-seeker, and there is no doubt but that this place does combine health and rest with pleasure.

The water of these two springs bubbles up from underneath a huge rock (diabase)—one at the rate of about 2 gallons per minute and the other somewhat less. It is the latter one that is used and the temperature of its water is 15.3° C. (58.5° F.). The water is bottled quite extensively and shipped. An analysis has been made of this water by Mr. H. B. Battle, who was formerly director of the North Carolina Agricultural Experiment Station. The results of the analysis are given below, where the constituents have been reported in their hypothetical form of combination:

ANALYSIS OF JACKSON SPRINGS MINERAL WATER.
No. 668.

Name and Formula.	Parts per 1,000,000.
Potash (K_2O)	2.6
Soda (Na_2O)	12.8
Lime (CaO)	16.6
Magnesia (MgO)	6.6
Ferric oxide (Fe_2O_3)	5.1
Manganese oxide (Mn_2O_4)	2.8
Sulphuric oxide (SO_2)	7.0
Chlorine (Cl)	6.8
Phosphoric oxide (P_2O_5)	trace
Silica (SiO_2)	39.2
Total solids at 110° C.	142.

HYPOTHETICAL FORM OF COMBINATION.

Name and Formula.	Parts per 1,000,000.	Grains per Gallon.
Sodium chloride (NaCl)	11.2	.65
Sodium sulphate (Na_2SO_4)	8.5	.50
Potassium sulphate (K_2SO_4)	4.8	.28
Sodium bicarbonate (NaHCO_3)	8.7	.51
Magnesium bicarbonate ($\text{Mg}(\text{HCO}_3)_2$)	24.1	1.41
Calcium bicarbonate ($\text{Ca}(\text{HCO}_3)_2$)	45.8	2.67
Calcium phosphate ($\text{CaH}_4(\text{PO}_4)_2$)	trace	trace
Ferrous bicarbonate ($\text{Fe}(\text{HCO}_3)_2$)	11.3	.66
Manganous bicarbonate ($\text{Mn}(\text{HCO}_3)_2$)	6.4	.37
Silica (SiO_2)	39.2	2.29
Total grains per gallon		9.34

EAGLE SPRINGS, MOORE COUNTY.

These springs are situated 1 mile southwest of Eagle Springs station, on the Aberdeen and West End Railroad. The chief spring is in sandy ground near a small stream. The flow is one-half a gallon per minute and the temperature (summer of 1897) was 15.6°C . There are no improvements except a small terra-cotta pipe enclosing the spring and a small summer house near by. The water is used locally.

ANALYSIS OF EAGLE SPRINGS MINERAL WATER.

No. 671.

Name and Formula.	Parts per 1,000,000.
Potash (K_2O)	2.5
Soda (Na_2O)	24.1
Lime (CaO)	13.7
Magnesia (MgO)	4.1
Ferric oxide (Fe_2O_3)	2.5
Sulphuric oxide (SO_3)	11.6
Chlorine (Cl)	5.0
Phosphoric oxide (P_2O_5)	.7
Silica (SiO_2)	30.5
Total solids at 110°C .	118.0

HYPOTHETICAL FORM OF COMBINATION.

Name and Formula.	Parts per 1,000,000.	Grains per Gallon.
Sodium chloride (NaCl)	8.2	.48
Sodium sulphate (Na_2SO_4)	16.3	.99
Sodium bicarbonate (NaHCO_3)	33.6	1.96
Potassium sulphate (K_2SO_4)	4.6	.27
Magnesium bicarbonate ($\text{Mg}(\text{HCO}_3)_2$)	14.9	.87
Calcium bicarbonate ($\text{Ca}(\text{HCO}_3)_2$)	39.9	2.32
Ferrous bicarbonate ($\text{Fe}(\text{HCO}_3)_2$)	5.5	.32
Silica (SiO_2)	30.5	1.78
Total grains per gallon		8.99



A, JACKSON SPRINGS HOTEL, JACKSON SPRINGS, N. C.



B, THE LAKE, JACKSON SPRINGS, N. C.

LEMON SPRING, MOORE COUNTY.

This spring is situated about $2\frac{1}{2}$ miles from Lemon Springs station on the Seaboard Air Line Railway. The spring is well kept and issues from a terra-cotta pipe sunk into the ground. It is clear and without odor and flows at the rate of one-half gallon per minute. The temperature at the time the sample was taken (July, 1896) was 18° C. (64.4° F.)

ANALYSIS OF LEMON SPRING MINERAL WATER.

No. 652.

Name and Formula.	Parts per 1,000,000.
Potash (K_2O)	.7
Soda (Na_2O)	15.1
Lime (CaO)	71.4
Magnesia (MgO)	4.9
Ferric oxide (Fe_2O_3)	.7
Manganese oxide (Mn_2O_3)	.7
Sulphuric oxide (SO_3)	5.2
Chlorine (Cl)	7.4
Phosphoric oxide (P_2O_5)	trace
Silica (SiO_2)	42.9
Total solids at 110° C.	188.

HYPOTHETICAL FORM OF COMBINATION.

Name and Formula.	Parts per 1,000,000.	Grains per Gallon.
Sodium chloride ($NaCl$)	12.6	.73
Sodium sulphate (Na_2SO_4)	8.5	.49
Sodium bicarbonate ($NaHCO_3$)	7.5	.49
Potassium sulphate (K_2SO_4)	1.1	.06
Magnesium bicarbonate ($Mg(HCO_3)_2$)	17.9	1.04
Calcium phosphate ($CaH_4(PO_4)_2$)	trace	
Calcium bicarbonate ($Ca(HCO_3)_2$)	207.1	12.08
Ferrous bicarbonate ($Fe(HCO_3)_2$)	1.5	.09
Manganous bicarbonate ($Mn(HCO_3)_2$)	1.6	.09
Silica (SiO_2)	42.9	2.50
Total grains per gallon		17.57

STROWD CHALYBEATE SPRING, ORANGE COUNTY.

This spring is situated about one-half mile northeast of Chapel Hill, within a few hundred yards of the Durham road. It has been cleaned out but has not been otherwise improved. It is used locally. There is a considerable deposit of iron hydroxide and basic carbonate in the outflow. The water has a decided iron taste. The flow is about one-half gallon per minute and the temperature in the summer is 15.5° C.

ANALYSIS OF STROWD CHALYBEATE SPRING
MINERAL WATER.

No. 606.

Name and Formula.	Parts per 1,000,000.
Potash (K_2O)	.8
Soda (Na_2O)	7.1
Lime (CaO)	9.1
Magnesia (MgO)	13.8
Ferric oxide (Fe_2O_3)	81.5
Sulphuric oxide (SO_3)	1.1
Chlorine (Cl)	8.0
Phosphoric oxide (P_2O_5)	trace
Silica (SiO_2)	23.6
Total solids at 110^0 C.	180.0

HYPOTHETICAL FORM OF COMBINATION.

Name and Formula.	Parts per 1,000,000.	Grains per Gallon.
Sodium chloride ($NaCl$)	13.2	.77
Potassium sulphate (K_2SO_4)	1.5	.09
Magnesium bicarbonate ($Mg(HCO_3)_2$)	44.4	2.59
Calcium phosphate ($CaH_4(PO_4)_2$)	trace	trace
Calcium bicarbonate ($Ca(HCO_3)_2$)	25.3	1.53
Ferrous bicarbonate ($Fe(HCO_3)_2$)	181.3	10.57
Silica (SiO_2)	23.6	1.38
Total grains per gallon		16.93

TYSON SPRING, ORANGE COUNTY.

This spring is 6 miles from Chapel Hill and within a few hundred yards of the crossing of the Chapel Hill-Oxford road and the Hillsboro-Raleigh road. It is a strong, bold spring and the water has a local reputation. There are no improvements.

ANALYSIS OF TYSON SPRING MINERAL WATER.

No. 690.

Name and Formula.	Parts per 1,000,000.
Potash (K_2O)	1.0
Soda (Na_2O)	5.8
Lime (CaO)	23.7
Magnesia (MgO)	6.2
Ferric oxide (Fe_2O_3)	2.0
Sulphuric oxide (SO_3)	1.8
Chlorine (Cl)	3.6
Silica (SiO_2)	21.6
Total solids at 110^0 C.	128.0

HYPOTHETICAL FORM OF COMBINATION.

No. 690.

Name and Formula.	Parts per 1,000,000.
Sodium chloride (NaCl) -----	5.8
Sodium sulphate (Na ₂ SO ₄) -----	1.7
Potassium sulphate (K ₂ SO ₄) -----	1.8
Magnesium bicarbonate (Mg(HCO ₃) ₂) -----	2.6
Calcium bicarbonate (Ca(HCO ₃) ₂) -----	8.5
Ferrous bicarbonate (Fe(HCO ₃) ₂) -----	4.4
Silica (SiO ₂) -----	1.6

GUERRENT SPRING, ROCKINGHAM COUNTY.

This spring is located about 4 miles northwest of Ruffin. It comes up through a sandy soil near a small branch. There are no exposures of rock in the vicinity. The water accumulates in a section of terracotta pipe and this is the only way the spring has been improved. The temperature of the water is 13.8° C. when the air temperature is 18° C., and the flow is about 1½ gallons per minute. The water is very clear and has no odor or taste of any kind. It is used quite extensively locally and the people around the spring have great faith in its curative properties.

ANALYSIS OF GUERRENT SPRING MINERAL WATER.

No. 729.

Name and Formula.	Parts per 1,000,000.
Potash (K ₂ O) -----	.7
Soda (Na ₂ O) -----	9.3
Lime (CaO) -----	18.0
Magnesia (MgO) -----	6.9
Ferric oxide (Fe ₂ O ₃) -----	2.9
Sulphuric oxide (SO ₂) -----	4.5
Chlorine (Cl) -----	4.2
Silica (SiO ₂) -----	25.0
Total solids at 110° C. -----	104.0

HYPOTHETICAL FORM OF COMBINATION.

Name and Formula.	Parts per 1,000,000.	Grains per Gallon.
Sodium chloride (NaCl) -----	6.8	.40
Sodium sulphate (Na ₂ SO ₄) -----	6.6	.38
Sodium bicarbonate (NaHCO ₃) -----	8.1	.48
Potassium sulphate (K ₂ SO ₄) -----	1.8	.07
Magnesium bicarbonate (Mg(HCO ₃) ₂) -----	25.0	1.46
Calcium phosphate (CaH ₂ (PO ₄) ₂) -----	trace	trace
Calcium bicarbonate (Ca(HCO ₃) ₂) -----	51.8	3.02
Ferrous bicarbonate (Fe(HCO ₃) ₂) -----	6.4	0.37
Manganous bicarbonate (Mn(HCO ₃) ₂) -----	1.6	0.09
Silica (SiO ₂) -----	25.0	1.46
Total grains per gallon -----		7.73

There are no accommodations for guests and there is only one house near the spring. Close to the spring two log cabins have been built for the accommodation of guests.

HICK SPRING, RUTHERFORD COUNTY.

This spring is also known as the "Chalybeate Spring." It is in the town of Rutherfordton, on the bank of a small creek, and is subject to flooding when the creek rises. It has a very slow flow—only about one-fourth gallon per minute. The temperature of the water is 16.2° C. with an air temperature of 29° C. The water has a local reputation and is used locally. The only improvement that has been made is to sink a wooden box for the water to rise into. The water has no marked taste or odor and is very clear. It deposits a greenish sediment, which seems to be largely organic, on the sides of the wooden box.

ANALYSIS OF HICK OR CHALYBEATE SPRING MINERAL WATER.

No. 657.

Name and Formula.	Parts per 1,000,000.
Potash (K_2O)	1.2
Soda (Na_2O)	4.8
Lime (CaO)	4.4
Magnesia (MgO)	2.5
Ferric oxide (Fe_2O_3)	3.1
Manganese oxide (Mn_2O_4)	1.4
Sulphuric oxide (SO_3)	1.1
Chlorine (Cl)	6.0
Phosphoric oxide (P_2O_5)	trace
Silica (SiO_2)	8.2
Total solids at 110° C.	131.0

HYPOTHETICAL FORM OF COMBINATION.

Name and Formula.	Parts per 1,000,000.	Grains per Gallon.
Sodium chloride ($NaCl$)	.2	.59
Potassium sulphate (K_2SO_4)	2.1	.12
Magnesium bicarbonate ($Mg(HCO_3)_2$)	5.6	2.66
Calcium phosphate ($CaSO_4$)	trace	trace
Calcium bicarbonate ($Ca(HCO_3)_2$)	9.5	4.05
Ferrous bicarbonate ($Fe(HCO_3)_2$)	3.8	1.70
Manganous bicarbonate ($Mn(HCO_3)_2$)	3.2	.18
Silica (SiO_2)	8.2	1.64
Total grains per gallon		10.94

HENSON SPRING, RUTHERFORD COUNTY.

This spring is known locally as the "Sulphur Spring" and is located about 10 miles south of Rutherfordton. It is situated on the slope of a hill about midway between top and bottom and flows out at the foot

of a large poplar. There is only a very faint odor and taste of sulphur, but it seems to contain a good deal of organic matter and has a milky appearance. The spring has a flow of only 1 gallon in 2 minutes and the temperature of the water is 15.6° C. when the air temperature is 24° C. The water has some little local use, but there are no provisions made for visitors.

ANALYSIS OF HENSON SPRING MINERAL
WATER.

No. 719.

Name and Formula.	Parts per 1,000,000.
Potash (K_2O)	2.9
Soda (Na_2O)	8.7
Lime (CaO)	27.1
Magnesia (MgO)	3.2
Ferric oxide (Fe_2O_3)	2.5
Manganese oxide (Mn_2O_3)	2.8
Sulphuric oxide (SO_3)	7.5
Chlorine (Cl)	2.6
Hydrogen sulphide (H_2S)	trace
Silica (SiO_2)	37.2
Total solids at 110° C.	110.0

HYPOTHETICAL FORM OF COMBINATION.

Name and Formula.	Parts per 1,000,000.	Grains per Gallon.
Sodium chloride ($NaCl$)	4.4	0.25
Sodium sulphate (Na_2SO_4)	9.4	0.55
Sodium bicarbonate ($NaHCO_3$)	6.1	0.35
Potassium sulphate (K_2SO_4)	5.5	0.30
Magnesium chloride ($MgCl_2$)	4.4	
Magnesium bicarbonate ($Mg(HCO_3)_2$)	11.7	0.68
Calcium bicarbonate ($Ca(HCO_3)_2$)	78.7	4.58
Ferrous bicarbonate ($Fe(HCO_3)_2$)	5.5	0.32
Manganous bicarbonate ($Mn(HCO_3)_2$)	6.7	0.39
Hydrogen sulphide (H_2S)	trace	trace
Silica (SiO_2)	37.2	2.17
Total grains per gallon		9.59

LEWIS SPRING, RUTHERFORD COUNTY.

This spring is near the house of Mr. Tolliver Lewis, 6 miles east of Rutherfordton, in a little gully close to the side of a creek. It is uncared for and had to be cleaned out in order to secure the sample. The water is milky in appearance, slightly sweetish to the taste and leaves a bitter after taste. The temperature of the water is 15.4° C. when that of the air is 26° C. The flow is very small—about 1 gallon in ten minutes. The water is little used and there are no accommodations for visitors nearer than Rutherfordton.

ANALYSIS OF LEWIS SPRING MINERAL WATER.

No. 720.

Name and Formula.	Parts per 1,000,000.
Potash (K ₂ O)-----	.9
Soda (Na ₂ O)-----	1.9
Lime (CaO)-----	27.4
Magnesia (MgO)-----	2.3
Ferric oxide (Fe ₂ O ₃)-----	5.9
Sulphuric oxide (SO ₂)-----	.2
Chlorine (Cl)-----	4.0
Phosphoric oxide (P ₂ O ₅)-----	.1
Silica (SiO ₂)-----	35.8
Total solids at 110° C.-----	70.0

HYPOTHETICAL FORM OF COMBINATION.

Name and Formula.	Parts per 1,000,000.	Grains per Gallon.
Sodium chloride (NaCl)-----	3.6	0.21
Potassium sulphate (K ₂ SO ₄)-----	.5	0.03
Potassium bicarbonate (KHCO ₃)-----	1.3	0.08
Magnesium chloride (MgCl ₂)-----	2.5	0.15
Magnesium sulphate (MgSO ₄)-----	4.3	0.25
Calcium phosphate (CaH ₄ (PO ₄) ₂)-----	.3	0.02
Calcium bicarbonate (Ca(HCO ₃) ₂)-----	78.8	5.02
Ferrous bicarbonate (Fe(HCO ₃) ₂)-----	13.1	0.76
Silica (SiO ₂)-----	35.8	2.09
Total grains per gallon-----		8.61

MEISENHEIMER SPRING, CABARRUS COUNTY.

This spring is 8 miles west of New London, Stanly County. It is beside a creek and the water comes up through a sandy soil. There is a very distinct odor of hydrogen sulphide. The temperature is 17° C. (62.6° F.) and the flow is one-fourth gallon per minute.

ANALYSIS MEISENHEIMER SPRING MINERAL WATER.

No. 672.

Name and Formula.	Parts per 1,000,000.
Potash (K ₂ O)-----	.3
Soda (Na ₂ O)-----	12.4
Lime (CaO)-----	41.9
Magnesia (MgO)-----	5.1
Ferric oxide (Fe ₂ O ₃)-----	.9
Manganese oxide (Mn ₂ O ₄)-----	3.8
Sulphuric oxide (SO ₂)-----	6.5
Chlorine (Cl)-----	9.0
Phosphoric oxide (P ₂ O ₅)-----	trace
Silica (SiO ₂)-----	21.3
Total solids at 110° C.-----	142.0

HYPOTHETICAL FORM OF COMBINATION.

No. 672.

Name and Formula.	Parts per 1,000,000.	Grains per Gallon.
Sodium chloride (NaCl)-----	14.8	0.86
Sodium sulphate (Na ₂ SO ₄)-----	11.0	0.64
Potassium sulphate (K ₂ SO ₄)-----	.5	0.03
Magnesium bicarbonate (Mg(HCO ₃) ₂)-----	18.6	1.08
Calcium phosphate (CaH ₄ (PO ₄) ₂)-----	trace	trace
Calcium bicarbonate (Ca(HCO ₃) ₂)-----	121.1	6.86
Ferrous bicarbonate (Fe(HCO ₃) ₂)-----	2.0	0.12
Manganous bicarbonate (Mn(HCO ₃) ₂)-----	8.9	0.52
Silica, (SiO ₂)-----	21.3	1.24
Total grains per gallon-----		11.35

ROCKY RIVER SPRINGS, STANLY COUNTY.

These springs are situated at Rocky River Springs, in the southern part of Stanly County. They are five in number and are known as Arsenic Spring, Iron Spring, Sulphur Spring, Magnesia Spring and Blue Spring. The last one is not used. Samples for analysis were collected of only the first two. They are all included in a radius of 25 yards. They flow from a low bottom land lying between two small streams. All the springs have been dug out and a stone curbing built around them. A pavilion has been erected over each and there is a hotel near by for the accommodation of visitors.

The water from the Arsenic Spring is used largely at the hotel for drinking purposes. There is a whitish-yellow sediment deposited by the water which is collected and used for bathing purposes. The temperature of the water is about 16° C. (60.8° F.) and the flow is about three-fourths gallon per minute.

ANALYSES OF ROCKY RIVER SPRINGS MINERAL WATER.

Nos. 674, 673.

Name and Formula.	Arsenic Spring.	Iron Spring.
	Parts per 1,000,000.	Parts per 1,000,000.
Potash (K ₂ O)-----	.9	.6
Soda (Na ₂ O)-----	13.1	13.1
Lime (CaO)-----	41.0	40.6
Magnesia (MgO)-----	6.5	4.5
Ferric oxide (Fe ₂ O ₃)-----	2.9	2.8
Manganese oxide (Mn ₂ O ₄)-----	1.9	1.7
Sulphuric oxide (SO ₃)-----	15.2	13.0
Chlorine (Cl)-----	4.8	9.5
Phosphoric oxide (P ₂ O ₅)-----	trace	trace
Silica (SiO ₂)-----	38.9	38.4
Total solids at 110° C.-----	187.0	200.0

HYPOTHETICAL FORM OF COMBINATION.

Name and Formula.	Arsenic Spring.		Iron Spring.	
	Parts per 1,000,000.	Grains per Gallon.	Parts per 1,000,000.	Grains per Gallon.
Sodium chloride (NaCl) -----	7.2	.46	15.6	.91
Sodium sulphate (Na ₂ SO ₄) -----	20.1	1.21	10.6	.62
Potassium sulphate (K ₂ SO ₄) -----	1.7	.09	1.1	.06
Magnesium bicarbonate (Mg(HCO ₃) ₂) -----	23.7	1.38	16.4	.96
Calcium sulphate (CaSO ₄) -----	9.2	.54	12.0	.70
Calcium phosphate (CaH ₄ (PO ₄) ₂) -----	trace	trace	trace	trace
Calcium bicarbonate (Ca(HCO ₃) ₂) -----	106.9	6.23	101.1	5.90
Ferrous bicarbonate (Fe(HCO ₃) ₂) -----	6.5	.38	6.2	.36
Manganous bicarbonate (Mn(HCO ₃) ₂) -----	4.2	.25	3.9	.23
Silica (SiO ₂) -----	38.9	2.27	36.4	2.12
Total grains per gallon -----		12.81		11.86

The Iron Spring has a temperature of 16° C. and a flow of 2 gallons per minute.

The so-called "Sulphur Spring" has no odor of hydrogen sulphide.

MOORE SPRINGS, STOKES COUNTY.

This spring is located at Moore Springs, N. C., a few miles from Rural Hall, a station on the Southern Railway. The spring has been improved and developed and the water is being shipped quite extensively in barrels and in cases containing 12 half-gallon bottles. A hotel and several cottages furnish ample accommodations for guests. There are two of the springs, designated as spring No. 1 and spring No. 2, which are very similar in their chemical composition, as will be seen from the analyses below. Analyses of these springs have been made by Mr. F. A. Genth, Jr., of Philadelphia, who has reported the constituents in a hypothetical form of combination.

ANALYSES OF MOORE SPRINGS MINERAL WATER.

Name and Formula.	Grains per Gallon.	
	No. 1.	No. 2.
Sodium chloride (NaCl) -----	.44	.38
Sodium sulphate (Na ₂ SO ₄) -----	2.75	2.56
Potassium sulphate (K ₂ SO ₄) -----	1.78	1.20
Magnesium sulphate (MgSO ₄) -----	5.5	4.88
Magnesium bicarbonate (Mg(HCO ₃) ₂) -----	4.07	4.6
Calcium sulphate (CaSO ₄) -----	84.47	84.92
Ferrous bicarbonate (Fe(HCO ₃) ₂) -----	.30	.32
Aluminum oxide (Al ₂ O ₃) -----	trace	trace
Cupric oxide (CuO) -----	.08	.06
Lithia (Li ₂ O) -----	faint	faint
Hydrogen sulphide (H ₂ S) -----	trace	trace
Silica (SiO ₂) -----	1.30	1.65
Carbonic oxide (CO ₂) -----	undet.	undet.
Total grains per gallon at 100° C. -----	109.56	108.98

PIEDMONT IRON SPRING, STOKES COUNTY.

This and the following spring are $2\frac{1}{2}$ miles west of Danbury and 14 miles north of Walnut Cove on the Cape Fear and Yadkin Valley Railroad. They are both under the same spring house and issue from the same rock mass, though on different sides. One is chalybeate (iron) and the other is locally known as freestone. The springs are improved and the hotel for summer visitors is about 100 yards to the northeast. The chalybeate water is surrounded by moss and has a flow of about $\frac{1}{2}$ gallon per minute. The temperature was 14.6° C.

The freestone spring has a flow of one-half gallon per minute and the temperature (July, 1896) was 15.8° C. The water is clear and without any odor.

ANALYSES OF PIEDMONT SPRINGS MINERAL WATER.

Nos. 651, 649.

Name and Formula.	Piedmont Iron Spring.	Piedmont Freestone Spring.
	Parts per 1,000,000.	Parts per 1,000,000.
Potash (K_2O)	3.7	1.5
Soda (Na_2O)	2.4	4.5
Lime (CaO)	11.0	5.9
Magnesia (MgO)	2.6	1.4
Ferric oxide (Fe_2O_3)	5.2	1.1
Manganese oxide (Mn_2O_4)	3.5	
Sulphuric oxide (SO_3)	3.2	.8
Chlorine (Cl)	3.4	4.4
Phosphoric oxide (P_2O_5)	trace	trace
Silica (SiO_2)	17.9	10.8
Total solids at 110° C.	82.6	51.6

HYPOTHETICAL FORM OF COMBINATION.

Name and Formula.	Piedmont Iron Spring.		Piedmont Freestone Spring.	
	Parts per 1,000,000.	Grains per Gallon.	Parts per 1,000,000.	Grains per Gallon.
Sodium chloride ($NaCl$)	6.7	.39	7.7	.45
Potassium sulphate (K_2SO_4)	6.4	.37	2.5	.15
Magnesium bicarbonate ($Mg(HCO_3)_2$)	9.5	.55	5.1	.29
Calcium phosphate ($CaH_4(PO_4)_2$)	1.0	.05	trace	trace
Calcium bicarbonate ($Ca(HCO_3)_2$)	32.3	1.88	17.1	.99
Ferrous bicarbonate ($Fe(HCO_3)_2$)	11.4	.66	2.3	.13
Manganous bicarbonate ($Mn(HCO_3)_2$)	3.2	.47		
Silica (SiO_2)	17.9	1.04	10.8	.63
Total grains per gallon		5.41		2.64

WALNUT COVE SULPHUR SPRING, STOKES COUNTY.

This spring is 300 yards west of the junction of the Norfolk and Western and Cape Fear railroads at Walnut Cove. The spring is enclosed and the basin floored over, the water flowing from a pipe rising 3 feet 6 inches above the floor and curving so as to empty into a trough. The flow is less than 1 gallon per minute. There is no house in the immediate neighborhood. The water is used locally, but is not shipped. There is a slight odor of hydrogen sulphide. The temperature (July, 1896) was 15.4° C.

ANALYSIS OF WALNUT COVE SULPHUR SPRING
MINERAL WATER.

No. 653.

Name and Formula.	Parts per 1,000,000.
Potash (K_2O)	1.7
Soda (Na_2O)	31.0
Lime (CaO)	56.4
Magnesia (MgO)	9.9
Ferric oxide (Fe_2O_3)	.8
Sulphuric oxide (SO_3)	3.8
Chlorine (Cl)	14.2
Phosphoric oxide (P_2O_5)	trace
Silica (SiO_2)	26.8
Total solids at 110° C.	215.0

HYPOTHETICAL FORM OF COMBINATION.

No. 653.

Name and Formula.	Parts per 1,000,000.	Grains per Gallon.
Sodium chloride ($NaCl$)	24.1	1.40
Sodium sulphate (Na_2SO_4)	14.4	.25
Sodium bicarbonate ($NaHCO_3$)	23.9	1.68
Potassium sulphate (K_2SO_4)	13.0	.17
Magnesium bicarbonate ($Mg(HCO_3)_2$)	36.2	2.11
Sulphureted hydrogen (H_2S)	undt.	undt.
Calcium phosphate ($CaH_4(PO_4)_2$)	trace	trace
Calcium bicarbonate ($Ca(HCO_3)_2$)	163.5	9.53
Ferrous bicarbonate ($Fe(HCO_3)_2$)	1.9	.11
Manganous bicarbonate ($Mn(HCO_3)_2$)	trace	trace
Silica (SiO_2)	26.8	1.56
Total grains per gallon		16.81

MOUNT AIRY WHITE SULPHUR SPRING, SURRY COUNTY.

This spring is within 50 feet of the Ararat River and is 3 miles northeast of Mount Airy. The spring is enclosed with stone and is carefully kept. The water is very clear, but deposits a whitish sediment and has a comparatively strong odor of hydrogen sulphide. The flow is about one-half gallon per minute and the temperature was at the time of taking the sample (July, 1896) 13.8° C.

ANALYSIS OF WHITE SULPHUR SPRING MINERAL WATER.

No. 650.

Name and Formula.	Parts per 1,000,000.
Potash (K_2O) -----	4.8
Soda (Na_2O) -----	12.4
Lime (CaO) -----	21.2
Magnesia (MgO) -----	4.6
Ferric oxide (Fe_2O_3) -----	4.8
Sulphuric oxide (SO_3) -----	6.1
Chlorine (Cl) -----	4.6
Phosphoric oxide (P_2O_5) -----	trace
Silica (SiO_2) -----	20.7
Total solids at $110^0 C.$ -----	114.0

HYPOTHETICAL FORM OF COMBINATION.

No. 650.

Name and Formula.	Parts per 1,000,000.	Grains per Gallon.
Sodium chloride ($NaCl$) -----	7.	.45
Sodium sulphate (Na_2SO_4) -----	4.5	.26
Sodium bicarbonate ($NaHCO_3$) -----	11.0	.64
Potassium sulphate (K_2SO_4) -----	8.4	.49
Magnesium bicarbonate ($Mg(HCO_3)_2$) -----	16.8	.98
Sulphureted hydrogen (H_2S) -----	undt.	undt.
Calcium phosphate ($CaH_4(PO_4)_2$) -----		trace
Calcium bicarbonate ($Ca(HCO_3)_2$) -----	61.4	3.53
Ferrous bicarbonate ($Fe(HCO_3)_2$) -----	10.6	.61
Silica (SiO_2) -----	20.7	1.20
Total grains per gallon -----		8.21

VADE MECUM SPRING, STOKES COUNTY.

The Vade Mecum Spring is situated at Vade Mecum, near the center of Stokes County and $2\frac{1}{2}$ miles southwest of Moore's Knob. It is about 16 miles from Rural Hall, a station at the junction of the Greensboro and Wilkesboro and the Cape Fear and Yadkin Valley railroads, two branches of the Southern Railway system, stages making the trip two or more times a day between the station and the hotel.

For many years this spring has had a local reputation, but it was not until about 1900 that it became generally known outside the county. The company have erected two hotels, constructed an artificial lake, and have made the place into a popular resort.*

The spring is situated just above the main water level of a small creek, and until the improvements were made, the spring was covered with sand and mud with every flood of the creek. It has been improved by high cement walls and a cement floor, which prevents any overflow from the creek. In the middle of the floor an 18-inch terra-cotta pipe

*Since this manuscript was begun a fire has destroyed the hotels, but it is very probable they will be rebuilt before another season.

sinks to the outlet of the spring, this outlet being a fissure in the country rock 12 inches long and 2 inches wide. The water stands 18 inches deep in the pipe up to the overflow pipe. A rough estimate of the flow of the spring was 7 gallons per minute. The water has no odor and no effervescent gases were observed. The temperature is 18° C. A bottling establishment of considerable importance is run in connection with the hotels and the water is shipped to a great many places.

ANALYSIS OF VADE MECUM MINERAL WATER.*

No. 029.

Name and Formula.	Parts per 1,000,000.
Potash (K_2O)-----	8.40
Soda (Na_2O)-----	84.60
Lime (CaO)-----	656.80
Magnesia (MgO)-----	60.40
Ferric oxide (Fe_2O_3)-----	1.70
Sulphuric oxide (SO_2)-----	996.00
Chlorine (Cl)-----	9.00
Silica (SiO_2)-----	13.20

*A. S. Wheeler, analyst.

HYPOTHETICAL FORM OF COMBINATION.

Name and Formula.	Parts per 1,000,000.	Grains per Gallon.
Sodium chloride ($NaCl$)-----	11.09	.85
Sodium sulphate (Na_2SO_4)-----	177.40	10.29
Potassium sulphate (K_2SO_4)-----	15.00	.87
Magnesium bicarbonate ($Mg(HCO_3)_2$)-----	219.80	12.75
Calcium bicarbonate ($Ca(HCO_3)_2$)-----	97.75	5.67
Calcium sulphate ($CaSO_4$)-----	1,512.00	87.72
Silica (SiO_2)-----	13.20	.76

FUQUAY SPRING, WAKE COUNTY.

This spring is located about 13 miles southeast of Apex, Wake County, and about 4 miles from Verina. The property is owned by a joint-stock company. The spring is in a little hollow on the bank of a small branch and there are no houses at the spring, though there were some years ago, when the spring had a considerable reputation. Quite lately a small framed boarding-house has been built about 200 yards from the spring, but the accommodations for guests are very poor. The spring itself is small and flows up into a wooden box at about the rate of one-half gallon per minute. The temperature is 16.4° C. The water has no odor or taste when drunk, but leaves a bitter after taste in the mouth and generally colors a tin dipper yellow.

ANALYSIS OF FUQUAY SPRING MINERAL WATER.

No. 727.

Name and Formula.	Parts per 1,000,000.
Potash (K_2O)	1.0
Soda (Na_2O)	11.0
Lime (CaO)	27.9
Magnesia (MgO)	8.9
Ferric oxide (Fe_2O_3)	4.4
Manganese oxide (Mn_2O_4)	2.4
Sulphuric oxide (SO_2)	5.8
Chlorine (Cl)	4.0
Phosphoric oxide (P_2O_5)	.1
Silica (SiO_2)	52.0
Total solids at $110^\circ C.$	157.0

HYPOTHETICAL FORM OF COMBINATION.

Name and Formula.	Parts per 1,000,000.	Grains per Gallon.
Sodium chloride ($NaCl$)	6.5	.38
Sodium sulphate (Na_2SO_4)	7.5	.44
Sodium bicarbonate ($NaHCO_3$)	10.8	.59
Potassium sulphate (K_2SO_4)	1.9	.11
Magnesium bicarbonate ($Mg(HCO_3)_2$)	14.1	.61
Calcium bicarbonate ($Ca(HCO_3)_2$)	80.3	4.68
Ferrous bicarbonate ($Fe(HCO_3)_2$)	9.8	.57
Manganous bicarbonate ($Mn(HCO_3)_2$)	5.6	.33
Calcium phosphate ($CaH_4(PO_4)_2$)	.2	.02
Silica (SiO_2)	52.0	3.03
Total grains per gallon		10.76

MACON SPRING, WARREN COUNTY.

This spring is located about 1 mile from Warrenton, close to the bank of a small stream. The water comes up into a section of terra-cotta pipe about 4 feet deep. The water is very clear, has no odor, but has a slightly bitter taste. The flow is about 2 gallons per minute.

ANALYSIS OF MACON SPRING MINERAL WATER.

No. 718.

Name and Formula.	Parts per 1,000,000.
Potash (K_2O)	2.0
Soda (Na_2O)	8.0
Lime (CaO)	6.9
Magnesia (MgO)	2.3
Ferric oxide (Fe_2O_3)	.2
Sulphuric oxide (SO_2)	.5
Chlorine (Cl)	4.8
Phosphoric oxide (P_2O_5)	trace
Silica (SiO_2)	32.7
Total solids at $110^\circ C.$	70.0

HYPOTHETICAL FORM OF COMBINATION.

Name and Formula.	Parts per 1,000,000.	Grains per Gallon.
Sodium chloride (NaCl) -----	7.8	.46
Sodium bicarbonate (NaHCO ₃) -----	15.4	.90
Potassium sulphate (K ₂ SO ₄) -----	1.2	.07
Potassium bicarbonate (KHCO ₃) -----	2.7	.16
Potassium phosphate (KH ₂ PO ₄) -----	trace	trace
Magnesium bicarbonate (Mg(HCO ₃) ₂) -----	8.3	.48
Calcium bicarbonate (Ca(HCO ₃) ₂) -----	19.8	1.15
Ferrous bicarbonate (Fe(HCO ₃) ₂) -----	.3	.02
Silica (SiO ₂) -----	32.7	1.90
Total grains per gallon -----		5.14

The temperature of the water at the time of the visit was 13.6° C. and of the air, 28.8° C. The water has a considerable local reputation.

DESCRIPTION OF SPRINGS IN MOUNTAIN REGION.

DAVIS WHITE SULPHUR SPRING, ALEXANDER COUNTY.

This spring, formerly known as Alexandria, is 1½ miles north of Hiddenite, a station on the Taylorsville branch of the Southern Railroad. The water flows about 1 gallon in 3 minutes. It has a very perceptible odor and taste of hydrogen sulphide and bubbles of gas can be seen escaping from the water. It is situated at the base of a hill near the bank of Davis Creek at an altitude of 1,100 feet. The temperature, taken in the summer of 1897, was 17.4° C. (63.3° F.). This spring has been known for over a hundred years and has been used locally for a great many years. In the spring of 1905, Messrs. William J. and Robert L. Davis erected a small hotel for the accommodation of visitors, which was enlarged in 1906 and again 1907, and they now have 87 rooms (Pl. XIII). The buildings are neatly furnished and have all modern improvements, such as electric lights, hot and cold baths, sewerage system, etc. The buildings are delightfully located on a knoll in a grove of oak trees. The surrounding hills and mountains offer attractive walks. There is a resident physician in attendance at the hotel. Analyses show the spring to be a sulphur water of exceptional purity.



DAVIS SPRING HOTEL AND SPRING-HOUSE, HIDDENITE, N. C.

ANALYSIS OF DAVIS WHITE SULPHUR SPRING MINERAL
No. 679. WATER.

Name and Formula.	Parts per 1,000,000.
Potash (K_2O)	65.0
Soda (Na_2O)	4.3
Lime (CaO)	3.3
Magnesia (MgO)	2.3
Ferric oxide (Fe_2O_3)	1.3
Sulphuric oxide (SO_2)	5.0
Chlorine (Cl)	3.8
Phosphoric oxide (P_2O_5)	trace
Silica (SiO_2)	20.0
Sulphureted hydrogen (H_2S)	undet.
Total solids at $110^{\circ} C.$	158.0

HYPOTHETICAL FORM OF COMBINATION.

No. 677.

Name and Formula.	Parts per 1,000,000.	Grains per Gallon.
Sodium chloride ($NaCl$)	6.3	.37
Sodium sulphate (Na_2SO_4)	2.5	.15
Sodium bicarbonate ($NaHCO_3$)	160.4	9.35
Potassium sulphate (K_2SO_4)	7.9	.46
Magnesium bicarbonate ($Mg(HCO_3)_2$)	8.4	.49
Calcium phosphate ($CaH_4(PO_4)_2$)	trace	trace
Calcium bicarbonate ($Ca(HCO_3)_2$)	9.5	.65
Ferrous bicarbonate ($Fe(HCO_3)_2$)	2.9	.17
Silica (SiO_2)	20.0	1.17
Total grains per gallon		12.71

ALL HEALING SPRINGS, ALEXANDER COUNTY.

This spring is 6 miles from Taylorsville. It is in a bottom near a small branch and cased in a wood box. There is a small hotel near for the accommodation of visitors. The water has no odor or taste. It is used internally and for bathing. The flow is about 2 gallons per minute and the temperature (taken in the summer of 1897) was $14.8^{\circ} C.$ ($58.6^{\circ} F.$).

ANALYSIS OF ALL HEALING SPRINGS MINERAL WATERS.
No. 679.

Name and Formula.	Parts per 1,000,000.
Potash (K_2O)	2.6
Soda (Na_2O)	8.9
Lime (CaO)	22.9
Magnesia (MgO)	3.0
Ferric oxide (Fe_2O_3)	1.0
Sulphuric oxide (SO_2)	7.0
Chlorine (Cl)	4.0
Phosphoric oxide (P_2O_5)	trace
Silica (SiO_2)	25.2
Total solids at $110^{\circ} C.$	128.0

HYPOTHETICAL FORM OF COMBINATION.

No. 679.

Name and Formula.	Parts per 1,000,000.	Grains per Gallon.
Sodium chloride (NaCl)	6.5	.38
Sodium sulphate (Na ₂ SO ₄)	8.5	.50
Sodium bicarbonate (NaHCO ₃)	4.6	.27
Potassium sulphate (K ₂ SO ₄)	4.8	.28
Magnesium bicarbonate (Mg(HCO ₃) ₂)	10.9	.64
Calcium phosphate (CaH ₄ (PO ₄) ₂)	trace	trace
Calcium bicarbonate (Ca(HCO ₃) ₂)	66.2	3.86
Ferrous bicarbonate (Fe(HCO ₃) ₂)	2.2	.13
Silica (SiO ₂)	25.2	1.46
Total grain per gallon		7.52

WATTS CHALYBEATE SPRING, ALEXANDER COUNTY.

This spring is 10 miles west of Taylorsville. The water issues from near the bottom of a hill and is caught in a heavy wooden box. It flows at the rate of about 1 gallon per minute, and makes a deposit of iron oxide. The temperature of the water in the summer of 1897 was 14.4° C. (58° F.).

ANALYSIS OF WATTS CHALYBEATE SPRING MINERAL WATER.

No. 680.

Name and Formula.	Parts per 1,000,000.
Potash (K ₂ O)	2.5
Soda (Na ₂ O)	7.6
Lime (CaO)	9.8
Magnesia (MgO)	3.3
Ferric oxide (Fe ₂ O ₃)	4.0
Manganese oxide (Mn ₂ O ₄)	.5
Sulphuric oxide (SO ₂)	8.4
Chlorine (Cl)	3.6
Phosphoric oxide (P ₂ O ₅)	trace
Silica (SiO ₂)	26.8
Total solids at 110° C.	88.0

HYPOTHETICAL FORM OF COMBINATION.

Name and Formula.	Parts per 1,000,000.	Grains per Gallon.
Sodium chloride (NaCl)	5.9	.34
Sodium sulphate (Na ₂ SO ₄)	11.2	.65
Potassium sulphate (K ₂ SO ₄)	4.6	.27
Magnesium bicarbonate (Mg(HCO ₃) ₂)	12.0	.70
Calcium bicarbonate (Ca(HCO ₃) ₂)	28.3	1.65
Ferrous bicarbonate (Fe(HCO ₃) ₂)	3.8	.55
Manganese bicarbonate (Mn(HCO ₃) ₂)	1.1	.06
Silica (SiO ₂)	26.8	1.56
Total grains per gallon		5.78

LOWDERMILK SPRING, ALEXANDER COUNTY.

This spring is located 3 miles west of Taylorsville and near the bank of Lower Little River. Some years ago this spring had quite a reputation and was largely used by visitors. There are a number of cabins near the spring and these were always occupied in the summer. The spring is now uncared for, and had to be cleaned out before a sample could be taken.

ANALYSIS OF LOWDERMILK SPRING MINERAL WATER.
No. 325.

Name and Formula.	Parts per 1,000,000.
Potash (K_2O)	1.4
Soda (Na_2O)	71.5
Lime (CaO)	2.0
Magnesia (MgO)	5.8
Ferric oxide (Fe_2O_3)	12.0
Sulphuric oxide (SO_3)	4.3
Chlorine (Cl)	23.2
Hydrogen sulphide (H_2S)	.2
Phosphoric oxide (P_2O_5)	trace
Silica (SiO_2)	31.3
Total solids at $110^{\circ} C.$	214.6

HYPOTHETICAL FORM OF COMBINATION.

Name and Formula.	Parts per 1,000,000.	Grains per Gallon.
Sodium chloride ($NaCl$)	37.5	2.19
Sodium sulphate (Na_2SO_4)	5.5	.32
Sodium bicarbonate ($NaHCO_3$)	135.5	6.06
Sodium sulphide (Na_2S)	.5	.02
Potassium sulphate (K_2SO_4)	2.6	.15
Magnesium bicarbonate ($Mg(HCO_3)_2$)	21.0	1.22
Calcium phosphate ($CaH_2(PO_4)_2$)	trace	trace
Calcium bicarbonate ($Ca(HCO_3)_2$)	5.7	.33
Ferrous bicarbonate ($Fe(HCO_3)_2$)	26.7	1.55
Hydrogen sulphide (H_2S)	.2	
Silica (SiO_2)	31.3	1.83
Total grains per gallon		13.66

The water was milky and had a very decided odor and taste of hydrogen sulphide. The temperature of the water was $15.2^{\circ} C.$ with an air temperature of $33.2^{\circ} C.$ The flow was about 1 gallon in 4 minutes. The spring had no wooden or stone casing around it.

ASHEVILLE CHALYBEATE SPRING, BUNCOMBE COUNTY.

This is also known as Armstrong's Spring and is about 2 miles east of Asheville. The water has been sold in Asheville.

ANALYSIS OF ASHEVILLE CHALYBEATE SPRING
MINERAL WATER.

No. 626.

Name and Formula.	Parts per 1,000,000.
Potash (K_2O)	3.7
Soda (Na_2O)	9.2
Lime (CaO)	7.5
Magnesia (MgO)	7.2
Ferric oxide (Fe_2O_3)	3.5
Sulphuric oxide (SO_3)	8.0
Chlorine (Cl)	8.0
Silica (SiO_2)	38.8
Total solids at $110^{\circ}C$.	145.6

HYPOTHETICAL FORM OF COMBINATION.

Name and Formula.	Parts per 1,000,000.	Grains per Gallon.
Sodium chloride ($NaCl$)	13.5	.79
Sodium sulphate (Na_2SO_4)	3.0	.17
Potassium sulphate (K_2SO_4)	6.9	.40
Magnesium bicarbonate ($Mg(HCO_3)_2$)	26.3	1.54
Calcium sulphate ($CaSO_4$)	5.3	.31
Calcium bicarbonate ($Ca(HCO_3)_2$)	73.2	4.27
Ferrous bicarbonate ($Fe(HCO_3)_2$)	73.2	.45
Silica (SiO_2)	38.8	2.26
Total grains per gallon		10.19

GLEN MONT SPRING, BUNCOMBE COUNTY.

This spring, known at one time as Coggin's, is situated 7 miles north-east of Asheville and about $4\frac{1}{2}$ miles from the Western North Carolina Railroad. The flow is about one-half gallon per minute and the temperature in July, 1895, was $14.4^{\circ}C$. ($58^{\circ}F$). There are no improvements, and the spring water is only used to a limited extent locally.

ANALYSIS OF GLEN MONT SPRING MINERAL
WATER.

No. 627.

Name and Formula.	Parts per 1,000,000.
Potash (K_2O)	7.9
Soda (Na_2O)	4.6
Lime (CaO)	18.1
Magnesia (MgO)	6.7
Ferric oxide (Fe_2O_3)	3.5
Sulphuric oxide (SO_3)	6.8
Chlorine (Cl)	8.6
Silica (SiO_2)	34.2
Total solids at $110^{\circ}C$.	130.0

HYPOTHETICAL FORM OF COMBINATION.

Name and Formula.	Parts per 1,000,000.	Grains per Gallon.
Sodium chloride (NaCl) -----	7.6	.44
Potassium sulphate (K ₂ SO ₄) -----	4.7	.86
Magnesium bicarbonate (Mg(HCO ₃) ₂) -----	24.4	1.42
Calcium chloride (CaCl ₂) -----	5.3	.31
Calcium bicarbonate (Ca(HCO ₃) ₂) -----	46.0	2.68
Ferrous bicarbonate (Fe(HCO ₃) ₂) -----	7.7	.46
Silica (SiO ₂) -----	34.2	1.99
Total grains per gallon -----		8.15

SUTTON SPRING, BUNCOMBE COUNTY.

This spring is 2 miles east of Asheville, at the foot of Beaumont Mountain, and has a flow of about 1½ gallons per minute. The temperature of the water was 14.8° C. (July, 1895).

ANALYSIS OF SUTTON SPRING MINERAL WATER.

No. 629.

Name and Formula.	Parts per 1,000,000.
Potash (K ₂ O) -----	3.3
Soda (Na ₂ O) -----	8.2
Lime (CaO) -----	17.5
Magnesia (MgO) -----	5.8
Ferric oxide (Fe ₂ O ₃) -----	5.2
Sulphuric oxide (SO ₃) -----	7.1
Chlorine (Cl) -----	8.0
Silica (SiO ₂) -----	37.3
Total solids at 110° C. -----	123.5

HYPOTHETICAL FORM OF COMBINATION.

No. 629.

Name and Formula.	Parts per 1,000,000.	Grains per Gallon.
Sodium chloride (NaCl) -----	12.9	.75
Sodium sulphate (Na ₂ SO ₄) -----	7.6	.44
Potassium sulphate (K ₂ SO ₄) -----	6.1	.35
Magnesium bicarbonate (Mg(HCO ₃) ₂) -----	21.1	1.23
Calcium bicarbonate (Ca(HCO ₃) ₂) -----	50.6	2.95
Ferrous bicarbonate (Fe(HCO ₃) ₂) -----	11.3	.66
Silica (SiO ₂) -----	37.3	2.17
Total grains per gallon -----		8.55

ASHEVILLE WHITE SULPHUR SPRING, BUNCOMBE COUNTY.

This spring, also known as Carrier's, is situated 5 miles west of Asheville and is connected with the city by a trolley line. A large hotel was erected near by, but was lost by fire. This is now (1908) being rebuilt, and it is expected that this place will again become a

very popular resort. The spring is neatly enclosed and covered. It has a good flow and the temperature ranges from 15 to 16° C. (about 60° F.). There is a strong odor of hydrogen sulphide and bubbles of escaping gas can readily be detected.

ANALYSIS OF ASHEVILLE WHITE SULPHUR SPRING
MINERAL WATER.

No. 630.

Name and Formula.	Parts per 1,000,000.
Potash (K ₂ O) -----	1.6
Soda (Na ₂ O) -----	10.5
Lime (CaO) -----	27.2
Magnesia (MgO) -----	7.8
Ferric oxide (Fe ₂ O ₃) -----	1.4
Sulphuric oxide (SO ₂) -----	2.4
Chlorine (Cl) -----	11.0
Phosphoric oxide (P ₂ O ₅) -----	trace
Hydrogen sulphide (H ₂ S) -----	undet.
Silica (SiO ₂) -----	32.3

HYPOTHETICAL FORM OF COMBINATION.

Name and Formula.	Parts per 1,000,000.	Grains per Gallon.
Sodium chloride (NaCl) -----	20.5	1.20
Sodium sulphate (Na ₂ SO ₄) -----	2.0	.12
Potassium sulphate (K ₂ SO ₄) -----	2.9	.17
Magnesium bicarbonate (Mg(HCO ₃) ₂) -----	35.6	2.08
Calcium phosphate (CaH ₄ (PO ₄) ₂) -----	trace	
Calcium bicarbonate (Ca(HCO ₃) ₂) -----	78.7	4.59
Ferrous bicarbonate (Fe(HCO ₃) ₂) -----	3.1	.18
Hydrogen sulphide (H ₂ S) -----	undet.	
Silica (SiO ₂) -----	32.3	1.88
Total grains per gallon -----		10.22

BLACKWELL SULPHUR SPRING, BUNCOMBE COUNTY.

This spring is located in Buncombe County about 4 miles west of Alexander, a station on the Southern Railroad. It is close to the banks of a bold stream, but is sufficiently high above the stream not to be flooded by its overflow. There are ample accommodations for guests, and the spring has been carefully enclosed and protected. The water is very clear and leaves but very little deposit. It has a distinct odor of hydrogen sulphide. The flow of the spring is about three-fourths of a gallon per minute and the temperature 14.6° C.

ANALYSIS OF BLACKWELL SULPHUR SPRING
No. 634. MINERAL WATER.

Name and Formula.	Parts per 1,000,000.
Potash (K_2O)	3.8
Soda (Na_2O)	13.1
Lime (CaO)	30.0
Magnesium (MgO)	9.2
Ferric oxide (Fe_2O_3)	1.3
Sulphuric oxide (SO_2)	6.5
Chlorine (Cl)	1.2
Phosphoric oxide (P_2O_5)	undet.
Hydrogen sulphide (H_2S)	undet.
Silica (SiO_2)	30.9
Total solids at $110^\circ C.$	120.0

HYPOTHETICAL FORM OF COMBINATION.

	Parts per 1,000,000.	Grains per Gallon.
Sodium chloride ($NaCl$)	22.5	1.31
Sodium bicarbonate ($NaHCO_3$)	5.8	.34
Potassium sulphate (K_2SO_4)	7.0	.41
Magnesium bicarbonate ($Mg(HCO_3)_2$)	33.6	1.96
Calcium phosphate ($CaH_4(PO_4)_2$)		trace
Calcium bicarbonate ($Ca(HCO_3)_2$)	86.6	5.06
Ferrous bicarbonate ($Fe(HCO_3)_2$)	30.0	.17
Hydrogen sulphide (H_2S)	undet.	
Silica (SiO_2)	30.9	1.80
Total grains per gallon		11.05

CONNELLY SPRING, BURKE COUNTY.

This well-known spring is on the line of the Southern Railroad and is the property of the Connelly Springs Company. It is well improved and there are large buildings for the entertainment of guests. The spring is enclosed in a marble basin. The water is clear and flows at the rate of about one-half gallon per minute. There is no odor, but a metallic taste. The outflowing water gives an abundant deposit of ferric hydroxide. The temperature was $16.8^\circ C.$ (July, 1895). Commercial shipments of the water have occasionally been made.

ANALYSIS OF CONNELLY SPRING MINERAL
No. 628. WATER.

Name and Formula.	Parts per 1,000,000.
Potash (K_2O)	1.1
Soda (Na_2O)	1.2
Lime (CaO)	9.0
Magnesia (MgO)	1.0
Ferric oxide (Fe_2O_3)	7.2
Sulphuric oxide (SO_3)	.5
Chlorine (Cl)	2.0
Silica (SiO_2)	4.8
Total solids at $110^\circ C.$	42.5

HYPOTHETICAL FORM OF COMBINATION.

Name and Formula.	Parts per 1,000,000.	Grains per Gallon.
Sodium chloride (NaCl) -----	2.7	.16
Potassium chloride (KCl) -----	1.1	.06
Potassium sulphate (K ₂ SO ₄) -----	1.1	.06
Magnesium bicarbonate (Mg(HCO ₃) ₂) -----	2.6	.21
Calcium bicarbonate (Ca(HCO ₃) ₂) -----	26.0	1.52
Ferrous bicarbonate (Fe(HCO ₃) ₂) -----	16.0	.93
Silica (SiO ₂) -----	4.8	.28
Total grains per gallon -----		3.22

PIEDMONT SPRINGS, BURKE COUNTY.

These springs are about 16½ miles north of Morganton, on the bank of Upper Creek. There are two* springs, a sulphur spring and an iron spring. The latter is very little used and has been allowed to fill up, so no sample of this was taken. The sulphur spring has a flow of about one-quarter gallon per minute. The temperature of the water was 16.4° C. The odor of hydrogen sulphide is very faint, but the taste is very pronounced. The spring, which is built up with rock, is not very well cared for and is allowed to fill in with leaves. There was a small hotel that was formerly used to accommodate guests, but this has been given up.

ANALYSIS OF PIEDMONT SULPHUR SPRING MINERAL
No. 722. WATER.

Name and Formula.	Parts per 1,000,000.
Potash (K ₂ O) -----	9.7
Soda (Na ₂ O) -----	121.4
Lime (CaO) -----	1.7
Magnesia (MgO) -----	1.1
Ferric oxide (Fe ₂ O ₃) -----	2.3
Sulphuric oxide (SO ₃) -----	2.1
Chlorine (Cl) -----	78.0
Phosphoric oxide (P ₂ O ₅) -----	.1
Sulphureted hydrogen (H ₂ S) -----	undet.
Silica (SiO ₂) -----	17.7
Total solids at 110° C. -----	316.0

HYPOTHETICAL FORM OF COMBINATION.

Name and Formula.	Parts per 1,000,000.	Grains per Gallon.
Sodium chloride (NaCl) -----	126.4	7.37
Sodium bicarbonate (NaHCO ₃) -----	143.6	8.37
Potassium sulphate (K ₂ SO ₄) -----	4.6	.27
Potassium bicarbonate (KHCO ₃) -----	15.2	.89
Calcium phosphate (CaH ₄ (PO ₄) ₂) -----	.3	.02
Calcium bicarbonate (Ca(HCO ₃) ₂) -----	4.9	.29
Magnesium bicarbonate (Mg(HCO ₃) ₂) -----	4.9	.23
Ferrous bicarbonate (Fe(HCO ₃) ₂) -----	5.1	.30
Sulphureted hydrogen (H ₂ S) -----	undet.	undet.
Silica (SiO ₂) -----	17.7	1.03
Total grains per gallon -----		18.77

GLEN ALPINE SPRING, BURKE COUNTY.

This spring is situated 14 miles southwest of Morganton. It is protected by a stone basin. It is used for table water by the Glen Alpine Springs School. A large flocculent precipitate is formed by the water inflowing from one basin to another and escaping by exit trough. The flow is slight, about 1 gallon in 5 minutes. The temperature (late summer of 1897) was 15.4° C. (56.6° F.).

ANALYSIS OF GLEN ALPINE SPRING MINERAL WATER.

No. 676.

Name and Formula.	Parts per 1,000,000.
Potash (K ₂ O) -----	3.8
Soda (Na ₂ O) -----	10.4
Lime (CaO) -----	27.0
Magnesia (MgO) -----	5.2
Ferric oxide (Fe ₂ O ₃) -----	3.5
Manganese oxide (Mn ₂ O ₄) -----	.4
Sulphuric oxide (SO ₂) -----	10.5
Chlorine (Cl) -----	3.6
Phosphoric oxide (P ₂ O ₅) -----	trace
Silica (SiO ₂) -----	26.6
Total solids at 110° C. -----	120.0

HYPOTHETICAL FORM OF COMBINATION.

Name and Formula.	Parts per 1,000,000.	Grains per Gallon.
Sodium chloride (NaCl) -----	5.9	.34
Sodium sulphate (Na ₂ SO ₄) -----	14.5	.85
Potassium sulphate (K ₂ SO ₄) -----	7.0	.41
Magnesium bicarbonate (Mg(HCO ₃) ₂) -----	18.9	1.10
Calcium phosphate (CaH ₄ (PO ₄) ₂) -----	trace	.45
Calcium bicarbonate (Ca(HCO ₃) ₂) -----	78.0	trace
Ferrous bicarbonate (Fe(HCO ₃) ₂) -----	7.7	.45
Manganous bicarbonate (Mn(HCO ₃) ₂) -----	.9	.05
Silica (SiO ₂) -----	26.6	1.55
Total grains per gallon -----		5.20

LIMESTONE SPRING, CHEROKEE COUNTY.

This spring is 4 miles northeast of Murphy and about 100 feet east of the Valley River road connecting Murphy with Andrews. It is several hundred feet southwest of and well above Marble Creek. The water issues out of a mass of marble and flows at the rate of 3 gallons per minute. The temperature of the spring was 14° C.

ANALYSIS OF LIMESTONE SPRING MINERAL WATER.
No. 639.

Name and Formula.	Parts per 1,000,000.
Potash (K_2O)	1.8
Soda (Na_2O)	2.6
Lime (CaO)	46.1
Magnesia (MgO)	6.5
Ferric oxide (Fe_2O_3)	3.0
Sulphuric oxide (SO_3)	2.0
Chlorine (Cl)	6.2
Silica (SiO_2)	13.0
Total solids at 110° C.	165.0

HYPOTHETICAL FORM OF COMBINATION.

Name and Formula.	Parts per 1,000,000.	Grains per Gallon.
Sodium chloride ($NaCl$)	2.7	.16
Potassium sulphate (K_2SO_4)	3.3	.19
Magnesium bicarbonate ($Mg(HCO_3)_2$)	24.6	1.43
Calcium chloride ($CaCl_2$)	7.0	.41
Calcium bicarbonate ($Ca(HCO_3)_2$)	122.6	7.15
Ferrous bicarbonate ($Fe(HCO_3)_2$)	6.7	.39
Silica (SiO_2)	13.0	.75
Total grains per gallon		10.48

PATTERSON SPRING, CHEROKEE COUNTY.

This spring is 3 miles southeast of Murphy. The water issues from a sedimentary rock and flows at the rate of 1 gallon per minute, forming a deposit of iron hydroxide. The temperature of the water was 15° C.

ANALYSIS OF PATTERSON SPRING MINERAL WATER.
No. 642.

Name and Formula.	Parts per 1,000,000.
Potash (K_2O)	4.4
Soda (Na_2O)	18.3
Lime (CaO)	26.3
Magnesia (MgO)	6.4
Ferric oxide (Fe_2O_3)	8.1
Sulphuric oxide (SO_3)	10.9
Chlorine (Cl)	6.0
Phosphoric oxide (P_2O_5)	trace
Silica (SiO_2)	24.9
Total solids at 110° C.	144.0

HYPOTHETICAL FORM OF COMBINATION.

Name and Formula.	Parts per 1,000,000.	Grains per Gallon.
Sodium chloride (NaCl)	10.2	.59
Sodium sulphate (Na_2SO_4)	13.5	.79
Sodium bicarbonate (NaHCO_3)	12.3	.72
Potassium sulphate (K_2SO_4)	7.7	.45
Magnesium bicarbonate ($\text{Mg}(\text{HCO}_3)_2$)	24.2	1.41
Calcium phosphate ($\text{CaH}_4(\text{PO}_4)_2$)	trace	trace
Calcium bicarbonate ($\text{Ca}(\text{HCO}_3)_2$)	76.3	4.45
Ferrous bicarbonate ($\text{Fe}(\text{HCO}_3)_2$)	17.8	1.04
Silica (SiO_2)	24.9	1.45
Total grains per gallon		10.90

TORPLEY YOUNG SPRING, CHEROKEE COUNTY.

This spring is situated about 1 mile east of Valletown. It had a flow of 2 gallons per minute and a temperature of 14°C .

ANALYSIS OF TORPLEY YOUNG SPRING MINERAL WATER.

No. 643.

Name and Formula.	Parts per 1,000,000.
Potash (K_2O)	6.2
Soda (Na_2O)	7.0
Lime (CaO)	27.5
Magnesia (MgO)	5.6
Ferric oxide (Fe_2O_3)	7.3
Sulphuric oxide (SO_3)	10.3
Chlorine (Cl)	7.5
Silica (SiO_2)	19.6
Total solids at 110°C .	125.0

HYPOTHETICAL FORM OF COMBINATION.

Name and Formula.	Parts per 1,000,000.	Grains per Gallon.
Sodium chloride (NaCl)	12.9	.75
Sodium sulphate (Na_2SO_4)	1.2	.07
Potassium sulphate (K_2SO_4)	11.1	.65
Magnesium bicarbonate ($\text{Mg}(\text{HCO}_3)_2$)	20.4	1.19
Calcium sulphate (CaSO_4)	8.3	.48
Calcium bicarbonate ($\text{Ca}(\text{HCO}_3)_2$)	69.8	4.07
Ferrous bicarbonate ($\text{Fe}(\text{HCO}_3)_2$)	16.1	.94
Silica (SiO_2)	16.6	1.14
Total grains per gallon		9.29

HAYWOOD WHITE SULPHUR SPRING, HAYWOOD COUNTY.

This spring is located about 1 mile west from Waynesville. This property is another of those containing mineral springs of considerable note that have been built up more for resort purposes than for health, the mineral spring water, however, being one of the attractions of the

place. The hotel and annex contain about 90 rooms and is equipped with all modern conveniences, as hot and cold water, electric lights, etc. The grounds around the hotel comprise 50 acres and are picturesque and attractive, the wooded mountains rising to the rear of the hotel, and the Richland River flowing at the foot of the lawn in front of the hotel. The spring is enclosed in a stone basin and covered by an attractive pavilion. The flow of water is apparently several gallons per minute, but it could not be measured accurately. The temperature in July was 14° C. The spring has a distinct odor and taste of hydrogen sulphide.

ANALYSIS OF HAYWOOD WHITE SULPHUR SPRING
MINERAL WATER.

No. 646.

Name and Formula.	Parts per 1,000,000.
Potash (K_2O)	2.1
Soda (Na_2O)	9.7
Lime (CaO)	17.6
Magnesia (MgO)	2.6
Ferric oxide (Fe_2O_3)	.5
Sulphuric oxide (SO_2)	.7
Chlorine (Cl)	5.6
Phosphoric oxide (P_2O_5)	trace
Hydrogen sulphide (H_2S)	undet.
Silica (SiO_2)	23.5
Total solids at 110° C.	100.0

HYPOTHETICAL FORM OF COMBINATION.

Name and Formula.	Parts per 1,000,000.	Grains per Gallon.
Sodium chloride ($NaCl$)	9.5	.55
Sodium sulphate (Na_2SO_4)	9.8	.57
Potassium sulphate (K_2SO_4)	3.6	.21
Magnesium bicarbonate ($Mg(HCO_3)_2$)	9.5	.55
Calcium phosphate ($CaH_4(PO_4)_2$)	trace	trace
Calcium bicarbonate ($Ca(HCO_3)_2$)	4.93	2.87
Lithium bicarbonate ($Li(HCO_3)_2$)	trace	trace
Ferrous bicarbonate ($Fe(HCO_3)_2$)	1.1	.06
Hydrogen sulphide (H_2S)	undet.	undet.
Silica (SiO_2)	23.5	1.37
Total grains per gallon		6.18

HAYWOOD CHALYBEATE SPRING, HAYWOOD COUNTY.

This spring, which is a strongly chalybeate one, is situated to the rear of the White Sulphur Spring Hotel and about 1 mile distant from the sulphur spring. The flow is from 1 to 2 gallons per minute and the temperature in the summer was very little below that of the air. There was a considerable deposit of iron hydroxide in the outflow. The spring was roughly walled in and kept clean, and is only used occasionally.

ANALYSIS OF HAYWOOD CHALYBEATE SPRING
MINERAL WATER.

No. 645.

Name and Formula.	Parts per 1,000,000.
Potash (K_2O)	3.0
Soda (Na_2O)	5.3
Lime (CaO)	18.0
Magnesia (MgO)	6.1
Ferric oxide (Fe_2O_3)	330.6
Sulphuric oxide (SO_2)	2.0
Chlorine (Cl)	7.6
Phosphoric oxide (P_2O_5)	trace
Silica (SiO_2)	34.8

HYPOTHETICAL FORM OF COMBINATION.

Name and Formula.	Parts per 1,000,000.	Grains per Gallon.
Sodium chloride ($NaCl$)	10.8	.63
Potassium sulphate (K_2SO_4)	5.3	.30
Magnesium bicarbonate ($Mg(HCO_3)_2$)	22.3	1.30
Calcium chloride ($CaCl_2$)	1.4	.08
Calcium phosphate ($CaH_4(PO_4)_2$)	trace	trace
Calcium bicarbonate ($Ca(HCO_3)_2$)	50.5	2.94
Ferrous bicarbonate ($Fe(HCO_3)_2$)	727.3	42.40
Silica (SiO_2)	134.8	7.86
Total grains per gallon		55.51

EPPS SPRING, SWAIN COUNTY.

This spring is located at the foot of East Canebrake Knob, about 5 miles west of Bryson City and 150 yards up Canebrake Branch from Epps Spring, a station on the Murphy branch of the Southern Railway. There is a small hotel, containing 12 rooms, that has been built for the accommodation of guests, which is within 50 yards of this spring, and has running water. There are 500 acres of ground belonging to the spring property, which is largely covered with timber, as oak, poplar, chestnut and some pine. Although there have been but little improvements made on this property, it offers a favorable location for building up a mineral spring resort, as the spring has exceptional medicinal properties, as is seen from the analysis given below. Canebrake Branch offers sufficient power to develop electricity for lighting the hotel.

The water from Epps Spring gushes out from the rock on the west side of a steep hill and is within about 30 feet of Canebrake Branch, but well above it. The flow of the spring is 1 gallon in 3 minutes. The temperature of the water was 60° F. in the summer of 1908.

About 60 yards from the Epps Spring and on the opposite side of

Canebrake Branch there is another spring, known as the Dairy Spring, which has also been analyzed, and, on account of the great contrast between the two, this analysis is also given.

The analysis of the Epps Spring showed an unusually large amount of solid matter, about one-fourth of this being magnesium sulphate, epsom salts, which gives the spring very high medicinal properties. On the other hand, the Dairy Spring showed a small content of mineral matter, but is a very pure water. The analyses of these waters were made by Mr. A. S. Wheeler, of the University of North Carolina, who reported the results in a hypothetical form of combination, as follows:

ANALYSES OF EPPS SPRING AND DAIRY SPRING MINERAL WATERS.

Name and Formula.	Parts per 1,000,000.	
	Epps Spring.	Dairy Spring.
Sodium chloride (NaCl) -----	10.9	6.59
Sodium sulphate (Na ₂ SO ₄) -----	38.1	3.79
Potassium sulphate (K ₂ SO ₄) -----	13.8	2.78
Magnesium sulphate (MgSO ₄) -----	303.1	16.24
Calcium sulphate (CaSO ₄) -----	884.0	4.02
Magnesium bicarbonate (Mg(HCO ₃) ₂) -----	23.9	10.35
Calcium bicarbonate (Ca(HCO ₃) ₂) -----	61.6	1.97
Iron oxide (Fe ₂ O ₃) { -----	20.0	none
Alumina (Al ₂ O ₃) { -----	12.0	15.7
Free carbon dioxide gas (CO ₂) -----	noted	61.44
Silica (SiO ₂) -----	1367.4	
Total solids at 110° C. -----		

HYPOTHETICAL FORM OF COMBINATION.

Name and Formula.	Epps Spring.		Dairy Spring.	
	Parts per 1,000,000.	Grains per Gallon.	Parts per 1,000,000.	Grains per Gallon.
Sodium chloride (NaCl) -----	10.9	.63	6.59	.38
Sodium sulphate (Na ₂ SO ₄) -----	38.1	2.21	3.79	.21
Potassium sulphate (K ₂ SO ₄) -----	13.8	.80	2.78	.16
Magnesium sulphate (MgSO ₄) -----	303.1	17.57		
Magnesium bicarbonate (Mg(HCO ₃) ₂) -----	23.9	1.38	4.02	.23
Calcium sulphate (CaSO ₄) -----	884.0	51.28	16.24	.94
Calcium bicarbonate (Ca(HCO ₃) ₂) -----	61.6	3.57	10.35	.60
Ferric and aluminum oxide (Fe ₂ O ₃ , Al ₂ O ₃) -----	20.0	1.16	1.97	.11
Silica (SiO ₂) -----	12.0	.69		
Total grains per gallon -----		79.29		.63

PRODUCTION.

During the year 1907 there were 13 springs that reported a production of mineral water that was put on the market. The production amounted to 193,499 gallons valued at \$40,302, as compared with 158,680 gallons valued at \$31,413, the production of 1906. The aver-

age price per gallon received for the 1907 production was 21 cents, the price varying from 10 to 30 cents per gallon. Of this production a portion was shipped simply for table water and its value amounted to \$3,040; the balance of the production, valued at \$37,262, was shipped on account of the medicinal properties of the water.

In the following table is given a list of the springs that reported sales of mineral water during 1907, together with a statement regarding the number of guests that can be accommodated at the springs:

Spring and Address.	County.	Number of Guests Accommodated.
All Healing Spring, Taylorsville	Alexander	50
Barium Rock Spring, Barium Springs	Iredell	
Buckhorn Lithia Spring, Bullock	Granville	
Connelly Spring, Connelly	Burke	150
Haywood White Sulphur Spring, Waynesville	Haywood	250
Jackson Spring, Jackson	Moore	200
Mida Spring, near Charlotte	Mecklenburg	
Morris Spring, Morris Springs	Stokes	450
Mount Vernon Springs, Mount Vernon	Chatham	100
Panacea Springs, near Littleton	Halifax	
Seven Springs, near Goldsboro	Wayne	100
Thompson Bromine-Arsenic Spring, Crumpler	Ashe	75
Vade Mecum Spring, Vade Mecum	Stokes	450

The Cleveland Spring, of Shelby, Cleveland County, which was a producer in 1906, did not report any production in 1907, while the Mount Vernon Springs reported a production for the first time in 1907.

In the following table there is given the quantity and value of mineral waters shipped for the years 1901 to 1907, inclusive:

PRODUCTION OF MINERAL WATERS IN NORTH CAROLINA
SINCE 1901.

Year.	Amount, Gallons.	Value.
1901	375,700	\$ 42,167
1902	104,400	18,795
1903	83,100	13,085
1904	145,800	21,602
1905	201,000	38,755
1906	158,680	31,413
1907	193,479	40,302

GRAPHITE.

The production of graphite in North Carolina has always been small and has never amounted to more than a few hundred tons per year. Its use has been for foundry facings and it is of rather inferior quality. During the past year, 1907, no graphite whatever was shipped. In the following table there is given the production of graphite from 1901 to 1907, inclusive:

PRODUCTION OF GRAPHITE IN NORTH CAROLINA FROM 1901
TO 1907.

Year.	Quantity.	Value.
	<i>Tons.</i>	
1901.....	95	\$ 559
1902.....	830	4,300
1903.....	50	248
1904.....	100	525
1905.....	100	475
1906.....	100	475
1907.....		

COAL.

The coal deposits have been described in some detail in previous reports and at no time has the production been of any large amount. In 1906 and 1907 there was no production whatever. In the table below the coal that has been produced in North Carolina since 1890, when the Cumnock Mine was reopened, is given:

COAL PRODUCTION IN NORTH CAROLINA FROM 1890 TO 1907.

Year.	Quantity.	Year.	Quantity.
1890.....	10,262	1899.....	26,896
1891.....	20,355	1900.....	17,734
1892.....	6,679	1901.....	12,000
1893.....	17,000	1902.....	23,000
1894.....	16,900	1903.....	17,309
1895.....	24,900	1904.....	7,000
1896.....	7,813	1905.....	1,557
1897.....	21,280	1906.....	0,000
1898.....	11,495	1907.....	0,000

PEAT.

Considerable interest has arisen during the past few years regarding the peat deposits in North Carolina in respect to their value for fuel, fertilizer and other purposes. As yet it has been impossible for the Survey to make any extended investigation regarding these deposits, but a small beginning was made in 1907 under the direction of Mr. Charles A. Davis, of the U. S. Geological Survey. In connection with his work, arrangements were made by which two car loads of peat were shipped from deposits on the outskirts of Elizabeth City, Pasquotank County, to the U. S. Geological Survey Fuel Testing Plant at the Jamestown Exposition, where it was tested. The results of this examination show the peat compares very favorably with peat that is being used for fuel purposes in Canada and European countries. It was hoped that there would be sufficient of the peat to make a producer gas test, but it was not possible to have this made. There is given in the following pages Mr. Davis' report:

PRELIMINARY REPORT OF PEAT DEPOSITS IN NORTH CAROLINA.

BY CHAS. A. DAVIS.

During the months of July and August, 1907, while making a preliminary study of the peat deposits of the coastal plain for the U. S. Geological Survey, a hasty examination of several localities in the sound region of North Carolina was made by the writer to determine, if possible, something of the origin and of the quality and quantity of peat in the well-known and extensive swamps of this part of the State.

Unfortunately, the work was not begun early enough to make a complete survey, but enough was done to make it apparent that in the region visited there are some deposits of sufficient extent and depth to serve as possible sources of large quantities of fuel, or as the basis of other industries.

In addition to this, sufficient data relating to the origin of the peat beds were collected to indicate the kinds of places to be examined for other deposits of sufficient depth and of the proper composition to make them of economic importance.

In recent years the constantly advancing price of coal and the increasing difficulty of getting a sufficient supply of either coal or wood for fuel, for industrial and domestic uses, has led to the seeking out of other sources of fuel supply, and among those which appear most promising is peat. It has for a long time been the most generally used fuel among the people of northern Europe, but in this country it is still practically an unknown, or at least undeveloped, resource.

Peat described.—Peat is partly decomposed vegetable matter which is accumulated in places in which the ordinary decay or decomposition of such materials is arrested, while the form, and a considerable part of the structure, of the constituent vegetation is more or less completely lost. Water, by excluding air and a large number of organisms which cause wood and other plant structures to rot and finally disappear altogether, makes an excellent medium for the accumulation of peat, and in general it may be said that peat deposits are only formed in places where there is a permanent or nearly permanent supply of water, which either completely saturates or covers the accumulated plant debris as laid down.

Deposits of such plant material, which, while kept wet part of the time, are subjected to periodical drying out, do not form peat, but may

form the related substance, humus, which is of such importance in all agricultural lands as a source of plant food and as a conserver of moisture.

Peat may be described, then, as the brown or black material of vegetable origin which is found in all places where the ground is continually saturated by water. It varies in color from light brown to black, and in texture from incoherent, loosely-felted material, coarse and fibrous or even woody, to a nearly structureless, cheesy mass, which is nearly as plastic as clay or putty. In all cases, under natural conditions, peat is saturated, or nearly saturated, with water containing from 80 to 95, or even more, per cent of this substance. Dry peat is lighter in color than wet, and will usually float when placed in water, although this is not always true of some darker colored, plastic types, which become nearly as hard as stone when dry. Except for these, untreated dry peat is quite easily crumbled to powder when handled, and makes bulky and unsubstantial fuel which does not bear transportation well.

OCCURRENCE.

Peat occurs in all of the moist regions of the earth, but is most generally distributed where the rainfall is regular and abundant, and where the relative humidity of the atmosphere is constantly high, so that evaporation of the water from the land surface is reduced to a minimum. A third important factor favoring peat accumulation is the presence of numerous undrained depressions in the land surface in which water stands permanently, at a nearly constant level.

These conditions are most fully met in the cold-temperate regions of the earth, especially in the northern hemisphere, where there are extensive land masses with poorly drained surfaces because of their comparatively recent abandonment by the ice sheet of the Glacial Period of geological history. In North America, north of 40° north latitude, conditions such as have been described are general; hence peat is more abundantly and widely distributed in that portion of the continent than south of it, and in Canada thousands of square miles of land are covered to a considerable depth by peat, and the States along the boundary between the Dominion and the United States all have, in the aggregate, large areas of peat deposits.

Southward of these States, the higher temperatures, longer summers, more frequent droughts and absence of undrained depressions produce conditions unfavorable for peat formation, and deposits of this material are fewer and of less extent than farther north. A very important factor in this respect is the low relative humidity of the air for long

periods during the summers, which tends to keep the surface of the land constantly dry, and thus in such a state that peat cannot collect upon it, even though the vegetation is luxuriant.

In the coastal plain, however, even in the extreme south, there is a very heavy rainfall, and the relative humidity of the air is generally high; that is, the air has apparently all of the moisture it will hold, because of the nearness of the ocean, and a general local movement of the air from the sea towards the land.

These conditions increase the rainfall and check evaporation, both factors advantageous to the accumulation of peat. The unfavorable condition existing here, aside from occasional summer droughts, is the almost entire absence of undrained depressions. This is offset, however, by the fact that the shore region of North Carolina is recently elevated sea bottom, almost without relief forms of any sort, great areas of the land being so nearly level that the water which falls as rain is unable to drain away rapidly enough to prevent swamp conditions from arising. This, together with the other factors mentioned, makes peat formation possible, despite the general absence of depressions noted above.

Peat formation in the coastal plain—The Pocosons.—The peat on these flat, undrained plains was probably formed somewhat as follows, judging from the studies made of existing conditions in the tracts visited: The earliest vegetation to establish itself was grass-like. This, by its growth and partial decay, tended to hinder still further the draining away of the rainfall, so that marsh plants soon appeared on the wet soil. These were of the grass type also, sedges, rushes and other herbs with long, narrow leaves and vigorous horizontal underground stems and abundant roots, which made a compact turf. The ground-surface was slightly raised by this, and, during dryer times, shrubs and trees gained a foothold upon it and sent their roots through the turf into the underlying mineral soil and made vigorous growth.

Upon the return of wet conditions, some of the types of woody plants were doubtless destroyed, but some, such as the cypress, sour gum and other species which will grow in excessively wet soil, persisted; those which were drowned out contributed to the ever-increasing accumulation of water-soaked vegetable matter and helped to check the run-off of the surface water.

The stages of development were doubtless quite varied, according to the size and elevation of the original area, its soil structure and slope, its distance from the margin of the ocean and the species of plants which were able to become the leaders in the plant association which originally took possession of the plain. It seems certain, however, that

a stage similar, or equivalent to, the open pocosons, known locally as "open grounds," now existing near the shores of the sounds, must have been passed through. Of these, the earliest observed stage was not far from Beaufort, near Wit post office. The chief vegetation here was a vigorous growth of sedges, grasses and other herbs, mingled with low shrubs, chiefly heaths growing in a substratum of sandy peat, covered by a dense growth of sphagnum moss. Forming clumps, or densely covering large areas, especially near the margins, were taller shrubs, also of the Heath family, bound together by a tangle of green brier and other vines, and growing over all, except for a large area in the most poorly drained parts, towards the center, was a sparse, open growth of the stunted Pond Pines. Towards the sound was a broad border of salt and brackish marsh without true peat. Examples of this type of pocoson are fully described by Ashe* in a previous report of this Survey.

The depth of peat in the areas visited was somewhat less than 4 feet. The peat was black, quite sandy, and of little prospective commercial value as fuel, since the sand would much reduce its heating value. A later stage of this type seemed to have a much more abundant growth of shrubs and broad-leaved trees, bound together by vines of several species, while the herbs and moss were less conspicuous and the pines larger and more thrifty in appearance. This stage, however, may have been due to less frequent fires, which in dry times often run through these swamps. Even if this is the cause of the difference in appearance between the stages, the facts noted are significant, in that they point to a definite and well-defined succession of types of plants, the earliest to appear being of the kinds which make the best peat.

The final or climax stage of this series of swamps formed on flat plains, which indefinitely repeats itself over and over, building up layer upon layer of the same sort of peat, seems to be a densely tree-covered, more or less wet swamp, in which locally the vegetation presents considerable variety, but with broad-leaved trees generally the dominant types, especially the sour or black gums, the red maple and the swamp oaks. The cypress is often distributed among the other types, but is frequently not present, or only in very wet places. The same statements may be made for the white cedar or juniper (*chama-cyparis thyoides*), which in some places forms dense, pure stands, in others is scattered through the hardwood growth, and in still others is entirely wanting. Below the trees, growing on the elevations around their root crowns and on fallen logs, will often be found shrubs, vines and the cane with lower-growing herbaceous plants.

*W. W. Ashe in Biennial Report of the State Geologist, 1905-06, pp. 40-46.

In some of these swamps peat occurs, but it is usually shallow, even in the Great Dismal Swamp, the most extensive of this type having rarely a depth of more than 6 feet, and is full of roots, fallen logs and the partially decayed stumps of past generations of dead trees. In the juniper swamps the number of buried logs is so large and their state of preservation so good that they have been dug out and used for lumber, and the peat in such swamps is reported to be little else than a mass of roots and logs lying together in a tangled mass.

Because of this structure and the shallowness of the beds of peat which have been formed in these coastal plain swamps, little can be expected of them as a basis of commercial development of fuel or other industries, except on a very small scale, perhaps, for local use, since the cost of digging out the peat and preparing it for market would be prohibitive.

More thorough investigation of some of these swamps may develop the fact that there are limited areas in which peat of better quality and greater depth exists. This is hardly to be expected, however, as both the geological structure of the country and the laws governing the growth of the plants which have formed the peat are opposed to such a possibility. The conditions have been such that tree growth began early in the history of the development of the peat and has been continued till the present time. Doubtless, in many cases it preceded it, and by shading the soil and keeping it wet, has contributed indirectly to peat formation as well as directly by furnishing a considerable part of the vegetable matter which has been preserved as peat. In numerous instances confirmation of this may be seen now around the outlying borders of most of the peaty areas, where the trees are well established under swampy conditions without any deposit of peat having formed.

The timbered pocoson, in which no peat has yet appeared, is a variant from the type, which doubtless will change into a peaty area as the accumulation of vegetable matter reaches such a point that the water is no longer able to drain off from or into the soil. At present, the vegetable matter falling to the ground is so often and so thoroughly dried and aerated that the organisms producing decay convert it into humus; but as this may accumulate faster than it is dissipated, in the end a condition of permanent wetness would be induced and peat formation would begin. This seems to be the condition on the western side of the Great Dismal Swamp in Virginia, where, at the outer edge of the swamp, there is no peat accumulation, but a mile or more into the swamp shallow peat is pretty generally present. The same thing was noted in the vicinity of Belhaven and near Newport, and is doubtless

generally to be observed around the margins of the greater swamp areas. In the smaller swamps drainage may be sufficient always to keep the average conditions such that no peat forms, although there may be prolonged wet periods which maintain the general swamp conditions.

The Marginal Swamps.—This name is given to a type of peat accumulations which are peculiar to the coastal plain and were first studied by the writer near Elizabeth City, where just north of the town, on the line of the Norfolk and Southern Railroad, is an excellent example.

Such swamps are marginal to the sounds, or the estuaries of the streams flowing into them, and have peaty deposits underlying them to a much greater depth than do the pocosons. The observed examples of the kind under discussion seemed to have formed in slight indentations of the shore line on which they occurred. These were long in proportion to their width, which was not very great.

The peat in the deposit at Elizabeth City was more than 16 feet deep and, where tested, had the following structure:

Record of a boring in the peat deposit north of Elizabeth City, in the open marsh near a sawmill siding: Surface growth, shrubs, sedges, saw-grass and cane.

- 0-2 feet—Turf of sedge roots and stems, tree and shrub roots, etc.
- 2-2 ½ feet—Soft, brown peat with many bits of wood.
- 4-4 ½ feet—Soft, brownish-black peat, well decomposed, plant remains, roots and stems of sedges and of yellow water lily.
- 6-6 ½ feet—Soft, brownish-black, well-decomposed peat, with parts of cane leaves and rootstocks.
- 8-8 ½ feet—Dark-brown, plastic, well-decomposed peat, with bits of grass-like plants. Hydrogen sulphide odor strong.
- 10-10 ½ feet—Plastic, dark-brown, somewhat silty peat; cane or grass rootstocks and fragments of water plants.
- 12-12 ½ feet—Plastic, dark-brown peat, containing cane rootstocks.
- 14-14 ½ feet—Good, plastic, dark-brown, fine-grained peat, fragments of leaves of water plants.
- 16-16 ½ feet—Plastic, dark-brown, fibrous peat, with strong odor of hydrogen sulphide; no wood or silt.

Most of the section gave an odor of hydrogen sulphide and considerable of the gas came up through the test holes. No wood or logs were encountered and very little silt was found in the samples. Several other tests were made, with about the same results, except that occasionally at a number of stations wood was found at various depths. Well-preserved cane remains were also common to the limit of the soundings—about 17 feet below the surface.

ECOLOGICAL AND GEOLOGICAL SIGNIFICANCE OF THE MARGINAL SWAMPS.

The character of the recognizable plant remains in the material found in these borings gives evidence that the deposition occurred under conditions which must be interpreted in one of two ways, namely, that there had been a very slow but constant rise of the level of the water while the peat was building up, or that the land under the deposit was slowly subsiding while peat formation was progressing. Of these two hypotheses but one is tenable, since the water in question is directly connected with that of the ocean and it is definitely known that the surface of the ocean has not generally risen to the extent required to account for the peat accumulations under consideration.

The other alternative—the slow subsidence of the bottom as the peat was growing—must be accepted, and as this is in accordance with other well-known geological evidence, such as submerged valleys, the washing away of beaches and minor changes in the coast line from Long Island southward, it may be considered as proved that the peat in the marginal swamps has reached the depth which has been found, because the bottom upon which it has been building has sunk to that depth. Thus, the peat of these swamps is a measure of the actual amount of subsidence and of the rate of sinking.

The laws governing the growth of plants are such that each species is able to grow only where its roots can get a certain amount of air and water and its leaves a certain amount of light. If the roots of most land plants are submerged too deeply in water the plant dies, largely because the air is cut off from them, and even swamp plants are so nicely adjusted in their relations to the water level that a rise of the water a foot in the soil may very largely destroy certain species. This may be illustrated by the great areas of the common cane which, in a dead and dying condition, were seen by the writer in the Great Dismal Swamp during the summer of 1907. There had been a prolonged period of high water in the parts of the swamp where the cane was injured, and it had been unable to survive it.

Other plants are equally sensitive to similar changes. Hence, if it is found that throughout the peat there are well-preserved and perfectly recognizable characteristic parts of plants whose relation to the water level is certainly known or can easily be ascertained by an examination of the living plants on the surface of the swamp, it is evident that the fact may be safely deduced that water levels were about as they are at present during the whole time while the peat formation was going on. This could only mean that the rate of subsidence was equal to the

rate of building up by the plants, and, since the same species were recognized from top to bottom, it is also apparent that the climatic and other environmental conditions have been about uniform.

It would therefore be possible to use these deposits to measure the lapse of time since the formation of the peat began, and, with less certainty, perhaps, the length of time during which subsidence in this area has been in progress, for it would be merely a matter of determining by observation for some years the rate at which the peat is growing at present and use this as a divisor into the total depth to find the length of time it has taken the whole to grow. A uniform rate of subsidence is shown by the uniformity of the constituent plants of the peat.

Such peat beds, then, may become the most definite and exact measures which have yet been found for determining the rate of the coastal subsidence and the length of time it has been in progress without a halt. If other evidence of the subsidence of the coastal plain were needed, that afforded by the living vegetation along the sounds where the water is fresh enough—as, for example, the shores of Albemarle Sound at Edenton and Mackey's Ferry—is conclusive. In this region on both shores are numbers of cypress trees growing in the open water of the sound at considerable distances from the shore. These trees are of rather small size and cannot be of very great age, yet it is certain at the time when they started from the seed they were on soil which, while it may have been near the water level, was not permanently below it; therefore, it is evident that the coast has sunk during the lifetime of these trees an amount at least equal to the difference between the mean high-water mark and the level of the early roots of the trees—a matter of several feet.

As above stated, the peat of the beds at Elizabeth City was compact, plastic, nearly black near the surface, but dark-brown below a depth of two or three feet, becoming blackish after a short exposure to the air. The structure of this deposit was quite uniform where tested, except for the partially decayed logs found here and there. These did not seem numerous enough to affect the value of the peat, however, and in most places none were encountered.

EXPERIMENTAL USE OF ELIZABETH CITY PEAT BY U. S. GEOLOGICAL SURVEY.

A quantity of this peat, amounting to several car loads, was dug out and sent to the fuel-testing plant of the Technological Branch, U. S. Geological Survey at the Jamestown Exposition. The peat was received at the Exposition grounds in the wet state, as dug from the bog, and was run through a peat press of Gerinan construction which ground and compacted it and formed it into bricks having a cross-section

of about 3 x 4 inches when wet, but shrinking about one-quarter on drying. These bricks were then dried by exposure to the air, becoming quite firm and tough when dry.

A preliminary proximate analysis made by the writer gave the following as the composition of this peat. The sample analyzed was taken from about 4 feet below the surface and was dried carefully at 100° C. before analysis.

Analysis of Peat from Elizabeth City, N. C.

Volatile matter	67.41 per cent.
Fixed carbon	23.74 per cent.
Ash	8.88 per cent.
B. T. U. (fuel value) not determined.	

This compares well with peat from other regions, being neither so good nor so poor as some, but is good fuel if properly prepared.

Several swamps of the same, or very similar, character were seen in the sound region, but were not examined for peat. There seems no good reason, however, why these should not have peat deposits of the same nature and origin as the one described. Such swamps were observed both north and south of Elizabeth City, and near Edenton, and these were all quite favorably situated near the line of the Norfolk and Southern Railroad, in case examination shows that they contain peat in sufficient quantity and of the right quality to warrant the development of fuel or other industries upon them.

This type of peat deposit has much greater commercial possibilities than that which occurs in the *pocoson* type of swamp, since the beds can be deeper, and are likely to be freer from tree remains. On the other hand, however, care should be taken in prospecting to avoid swamps which have been exposed to flooding by storm waters containing much sand or mud, or those near the mouths of streams which in flood time bring down large quantities of silt and mud and deposit them in the swamps, as from these sources the peat may become too high in ash to be of any value as fuel. For the same reason the swamps which have developed along the flood plains of rivers and on the delta deposits at their mouths are not likely to contain peat which can be used as fuel, especially where the streams are heavily charged with silts, as is the case with most of those in the region under consideration.

It is evident from the foregoing discussion that all gritty or sandy peats, or those made up largely of woody plants in which the wood is not thoroughly broken down by decay, are to be considered as unavailable at present for fuel purposes.

USES OF PEAT.

Fuel.—Peat has been used for fuel more than for any other purpose, and certain kinds of it are unsuited for any other use. As a fuel, it is highly satisfactory for cooking and heating stoves, as it is clean, light in weight, and with properly regulated drafts and suitable grates it burns freely, giving an even, intense heat, with little objectionable smoke and no cinders, clinkers or corrosive effects on grates or fire boxes. It also burns for a very long time—until it is entirely consumed, in fact, when deprived of draft. The ash is bulky but light in weight, and although it varies much in different kinds of peat, those which have 20 per cent or over are not considered sufficiently high in heating power to be worth trying to make into a commercial product. Such would still be usable for fuel by individuals on a small scale or for peat gas.

Peat is also a good fuel for use under steam boilers, requiring for the best results, when used for this purpose, rather larger fire boxes and less grate space than either wood or coal. When freshly fed to the fire under boilers it burns with a clear, bright, nearly smokeless flame of intense heat, and, after the gases are all consumed, continues to burn with a steady, strong heat until it is wholly used up. The same advantages are claimed for it in steam and power production as in domestic uses, the only drawbacks being its bulkiness, as compared with coal, since several times the space and storage is required for it as for coal of the same heating value, and the more frequent firing necessary. These are more than offset, however, by the ease of handling, the absence of clinkers and waste and the freedom from smoke and corrosive gases.

Cut peat.—The form of peat fuel which has been in general use for generations among the people in most countries of northern Europe is cut peat. The only preparation given this is to cut it from the bog in oblong blocks with the slane, a tool like a long spade, with a sharp, cutting spur a few inches long welded at right angles to the bottom, and to expose it to the sun and air until it is dry enough to pile in open stacks.

Machine peat.—In order to increase the fuel value of this product, which is somewhat higher than that of wood, and at the same time to secure a more compact and less friable fuel, many types of machinery have been devised during the past century. The simplest and least expensive of these, and perhaps the most efficient as well, grinds the peat, wet, as it comes from the bog, kneads and compacts it and forces it from the outlet in a long prism or cylinder which is cut into bricks and delivered on pallets or short boards as fast as made. These are

taken to drying grounds where, in a short time, they become sufficiently firm to handle and may be stacked and left to dry more completely. Such air-dried blocks make a good fuel, considerably superior to wood in heating value, and may be readily handled without breaking. Fuel thus prepared is known as machine, condensed, or compressed peat, although little compression is used in its preparation. The grinding and kneading to which it is subjected in the machine reduce the volume of the crude peat about one-third.

The processes described above can only be carried on during the summer months in northern climates where they have been developed, and it is especially desirable to continue the making of peat into fuel during the entire year, since then the plant and men employed will not be idle for any long period. Many attempts have been made, therefore, to devise some process by which the peat can be dried artificially and converted into a compact form, regardless of wet weather and of the seasons. By this means also it has been hoped to develop a continuous output of high-class fuel sufficient to warrant the investment of large capital. Unfortunately, however, the very large per cent of water held in peat is so tenaciously retained by it that it is only given up by the application of heat; pressure, filtering and other means usually employed to separate solids from liquids have little effect to free the peat from water, as has been proven abroad by exhaustive and costly experiments on a factory scale.

Peat briquettes.—After the peat has been artificially dried and powdered, it may be compressed into blocks of various convenient shapes by the application of great pressure. Such blocks, known as peat briquettes, have a considerably higher fuel value than either cut or machine peat, are more compact, firm and easier to handle than blocks of other types, and at the same time they do not disintegrate readily in the fire, or when exposed to a moderate amount of wetting, but may crumble if handled roughly. In this form peat is at its best, but, unfortunately, all of the plants established in this country to manufacture peat briquettes using the artificial drying system have been unsuccessful, and those abroad are reported by careful and competent investigators of the subject as not flourishing. This is undoubtedly due to the amount of fuel needed to drive the water out of the peat. The importance of this item is evident when it is understood that about three times the number of heat units must be used to produce a ton of dry peat as the ton will generate after drying, so that even if the fuel consumed for the purpose is waste material from the bog, a great amount of it must be gathered in proportion to the salable product

made; and the latter will not sell for sufficient to pay for this and its own preparation and selling, together with the cost of maintenance of the expensive plant necessary for its manufacture.

Peat coke.—Still more expensive is the plant necessary for the manufacture of peat coke, the form of peat fuel approaching nearest to anthracite coal in efficiency. This material, when made by the best processes, is as firm and hard as hardwood charcoal and is quite as valuable as that material for all metallurgical operations, such as smelting iron, copper and other ores, as well as for fuel purposes. In the production of peat coke by a recently developed commercial method—the Ziegler process—the peat is ground wet, formed into bricks and air-dried; it is then heated in closed iron retorts, the inflammable gases driven off being burned under the retorts to carry on the process, while the gases which will condense are saved; from them, by special treatment, are derived wood tar, methyl or wood alcohol, acetic acid, ammonia compounds, illuminating and lubricating oils. This process is fully covered by patents abroad and in this country and requires a considerable outlay of capital for even the smallest unit plant.

Comparison with other fuel.—For the purpose of comparing the fuel value of peat which has been given the various methods of treatment described above with other common types of fuel the following table is inserted. In considering the table, however, it should be remembered that the samples of peat given are not from the same source, and hence the relative values are only approximate.

COMPARISON OF HEAT VALUE OF VARIOUS FUELS.

Fuel.	B. T. U.
Wood.....	5,760
Ordinary air-dried cut peat.....	6,840
Pressed peat.....	7,290
Bituminous coal.....	11,000
Ordinary gas coke.....	12,060
Peat coke.....	12,676
Semi-bituminous coal.....	13,000
Peat briquettes.....	13,330
Charcoal.....	13,804
Anthracite.....	14,600
Peat coke, No. 1 (Ziegler process).....	14,800

The quantity of fuel used in these tests was 1 pound. The British thermal unit (B. T. U.) is the amount of heat necessary to raise a pound of water 1 degree Fahrenheit.

Figures of the American Society of Mechanical Engineers are, 1 ton anthracite equals 1.8 tons common air-dry peat or 2.5 tons pine wood. Air-dried peat has from 12 to 25 per cent water and loses about 1 per

cent of its heating value for each per cent of moisture which it gains. All forms of peat fuel, except the charcoal and coke, and possibly some very dense, black peats, take up moisture from the air until about in air-dry condition, hence are less efficient in very moist air than in dry.

Peat gas.—Peat yields a large amount of combustible gases compared with coal, when heated in retorts, and in Sweden and some other parts of northern Europe it is reported to be used for the production of illuminating gas on a large scale, even low-grade peat high in ash giving excellent results. The gas may be used in gas engines, seeming especially adapted to this use, and it has been proposed by European engineers to employ it by means of gas engines at the larger bogs to generate electricity for power and lighting, transmitting the current to manufacturing centers for use—a perfectly feasible plan if experiments confirm the theoretical possibilities.

Peat is a fuel which may be used in the suction types of producer-gas engines, comparing very favorably with some of the poorer bituminous coals for this purpose and yielding much more power used thus than when burned to generate steam. The use of all kinds of low-grade fuels in the producer-gas engine is, however, subject to certain disadvantages, which, up to the present writing, are only partially overcome, and it is only in large plants where competent mechanical engineers can be employed that such fuels are being tried.

Peat in agriculture.—Peat is perhaps of more importance in its agricultural uses than in any other, not excepting fuel. This is especially true in a region where soils are light and sandy and easily leached, as in much of the coast and trucking regions of North Carolina, where it is necessary to keep the land in a state of highest fertility to get the best results from the special crops which are raised. Peat in the raw state, as it comes from the bog, has little, if any, value when spread wet on the surface of the land, since it soon dries and forms hard lumps of inert organic matter which do not subsequently pulverize. If, however, it is cut out from the swamps and piled in heaps during the winter and allowed to stand till thoroughly dry and disintegrated and is then composted with stable or barnyard manure, it becomes a valuable material, furnishing a good absorbent for the liquid and gaseous parts of the manure and also for the ammonia compounds which would otherwise be lost. At the same time, a part of the 2 or more per cent of fixed nitrogen of the peat, entirely inert in the crude peat, is made available for the use of plants, and the whole mass becomes more or less converted into humus-like compounds, the thoroughness of these changes, however, depending somewhat on the type of peat originally used. One careful experimenter in this direction reported, after many tests, that

he considered a load of peat thus treated to be equal to a load of stable manure, and farmers in the regions where peat is common have long known that no better material could be found for use in barnyards as an absorbent. The chief sources of error in the use of the material lie in trying to use it for any such purpose in the wet and unmodified condition. The fallacy of drawing wet peat for the above use is shown when it is remembered that about 90 per cent of its weight is water, and that at least from one-half to two-thirds of this weight will disappear after the material has been heaped up on the surface of the ground for a sufficient time, while its mechanical and absorbent properties, as well as its chemical, are much improved by this treatment.

Peat as stable litter.—The coarser, less thoroughly decomposed kinds of peat, especially those in which mosses and grass-like plants form a large part of the material, make excellent stable litter and bedding for horses and cattle, being cheaper and much more absorbent than straw, and having a deodorizing and antiseptic effect not possessed by the usual materials. These properties render the peat litter especially valuable for use in dairy barns and in city stables. The moss-covered, "open grounds" in pocosons near the railroads, like that near Newport, for example, should be examined with a view to determining whether the moss could not be raked up and baled for litter for shipment to the cities farther north.

Peat as a deodorizer and disinfectant.—Dry, powdered peat is a most efficient deodorizer for use in cesspools, privy vaults, earth closets and urinals, excelling dry earth, ashes, or even lime in this respect. For this purpose it should be dried as thoroughly as possible and stored in barrels or bags under cover. In Europe, the finer material, obtained by screening out the coarser moss and other plant remains in preparing the peat litter for baling, is saved and sold for the above-mentioned uses, and machines for separating the two products automatically and delivering them to the packers are manufactured.

Peat filler for artificial fertilizers.—A rather recent use of peat on a large scale has developed in the manufacture of peat as a "filler" for those forms of artificial fertilizers in which tankage and other refuse animal matter is used as the source of a part, or the whole, of the nitrogen. For this use the peat is dried and pulverized and in this form is the best material yet found for mixing with the substances mentioned above; its absorbent qualities permit it to keep the mixture dry and thus prevent caking, and its antiseptic effects also probably prevent destructive bacterial fermentation and the loss of the nitrogen as free ammonia. If free ammonia is liberated, the peat, in part at least, may absorb it; and not the least of its valuable qualities in this

use is its deodorizing effect. On the other hand, the peat itself is not directly and immediately a fertilizer under ordinary conditions, since it will be slow to decompose; its 2 to 3 per cent of nitrogen, in combined form, may also appear in the analysis of the fertilizer and thus "pad" it, since it is in such combinations that it is not available for plants. In spite of these objections, its numerous and weighty advantages and its cheapness, together with the fact that ultimately it probably becomes a part of the humus of the soil and thus enriches it, make its use not only justifiable but almost necessary, if the cheap sources of nitrogen are to be fully utilized in the manufacture of the fertilizers, so important to the best interests of the agriculture of to-day.

Most of the dark-colored peats of the marginal swamps could be used for this purpose, and the simplicity of the process of preparation, the nearby markets and the excellent facilities for both land and water shipment should lead to an early development of an industry of this character upon some of the North Carolina peat beds.

Other uses of peat.—The uses of peat in paper and cardboard manufacture, fabric-making and some others need not be discussed here, since they require types of peat for their development which do not seem to be likely to be found in the coastal plain, since conditions are adverse to their occurrence.

Prospecting methods.—In the preliminary testing of a peat deposit the essential things to be considered are quantity, quality and availability. The quantity can be determined approximately by estimating or surveying the surface covered by the deposit and getting the average depth by borings made with a common two-inch ship auger welded to a short piece of one-half inch gas pipe. This should be fitted with a union so that it may be screwed to other sections of pipe and pushed down until the bottom of the peat is reached. If the rod is to be much used, sections should not exceed 4 feet in length, and each union should be permanently pinned to a section so that only one end will unscrew. The testing with the auger should be done systematically in straight lines, holes being made at approximately regular intervals and their location noted on a sketch map, together with the depth of peat.

Valuation of peat beds.—To estimate the quantity of dry fuel which can be made from a given deposit, conservative figures would be from 200 to 300 tons per acre for each foot in depth below the surface 2 or 3 feet. The quality of the peat is of equal importance to the quantity, since upon this depends the use which can be made of it. By quality may be understood the physical structure and chemical composition. Very coarse, woody, or poorly decomposed peat, or that which is very

sandy or muddy is not physically adapted to any use under existing conditions. Types of peat with much grass and sedge remains in them, while making good fuel by the wet process and by coking are not usually adapted to briquetting. The fuel value, ash and composition of the peat, can only be determined by chemical analysis, but besides the analytical study, before it is decided to build a plant at any peat deposit, large samples of the material should be tried to test its adaptability to the particular purpose for which it is intended to be used.

In selecting peat beds for exploitation the matter of markets and of transportation to them should be thoroughly considered, for the product, however desirable it is theoretically, must find a sure market and be delivered to it regularly and cheaply if the manufacturer is to make profitable sales. Peat fuel must be sold in competition with coal and wood, hence it must be disposed of at a moderate price. It is bulky and easily broken into fragments, so cannot be transported either by cart or rail very far over rough roads; it is injured by long exposure to rain, therefore it requires protection from the weather when stored or in transit. For these and other reasons the matter of market and transportation are paramount considerations, and otherwise most excellent deposits must remain unused because too remote from good markets, or from established transportation lines.

CONCLUSION.

The present outlook for peat, especially as fuel, seems to be in the careful development of small establishments to supply local demands wherever the price of other fuels is sufficient to warrant the introduction of a moderate-priced fuel adapted especially to domestic use. If such plants are properly planned and have good transportation facilities, they should be financially successful, as in such peat fuel can be produced ready to ship by the wet process for about \$1 per ton. If improvements are made in producer-gas engines so that small manufacturers can install and use them economically, using low grades of fuel, immediately a larger opportunity for peat fuel will be presented. In whatever direction utilization of the peat deposits of the State is begun, the work should be carried on carefully and as an experiment until sufficient knowledge of the markets and of the ways of handling the substance itself is acquired to insure success, for, judging by the failure of the plants in other States, in no other way can it be achieved.

STONE.

The production of building stone in North Carolina has been constantly increasing for the past twelve years, and during 1907 there was

a decided increase in the value of stone produced as compared with that of 1906, the total value of the production of all kinds of stone being \$956,919, which is an increase of \$102,618, as compared with \$854,301, the value of the production of 1906. Each year there is a greater amount of the stone produced used for building purposes and its market is being more widely extended. This is true not only of the stone for building, but also of the curbing and paving blocks for street work.

There is given in the table below the value of the production of various stones produced in North Carolina for the years 1900 to 1907, inclusive:

PRODUCTION OF BUILDING STONES IN NORTH CAROLINA, 1900-1907.

Year.	Granite.	Sandstone.	Marble and Limestone.	Total Value.
	<i>Value.</i>	<i>Value.</i>	<i>Value.</i>	
1900-----	\$ 257,962	\$ 27,210	\$-----	\$ 285,172
1901-----	264,906	11,682	8,357	284,945
1902-----	338,749	4,825	23,153	366,727
1903-----	334,357	600	25,365	360,322
1904-----	232,459	250	19,887	312,576
1905-----	564,425	4,482	29,015	597,922
1906-----	778,819	3,431	72,051	854,301
1907-----	906,476	4,105	46,338	956,919

* Statistics not collected for 1900.

GRANITE.

PRODUCTION.

The increase in the production of granite which has been noted for a number of years past, continued in 1907, and the value of the production, \$906,476, is an increase of \$127,657, as compared with \$778,819, the value of the 1906 production. The number of operators quarrying granite during 1907 was 33, an increase of 8 over the number quarrying during 1906. These operators worked 37 quarries in the following 16 counties, which are given in the order of the importance of their productions: Rowan, Surry, Rockingham, Warren, Buncombe, Polk, McDowell, Orange, Henderson, Vance, Nash, Guilford, Wake, Davidson, Anson and Gaston. Cabarrus and Catawba counties, which were producers in 1906, reported no production in 1907, while Anson, Guilford, Nash and Wake are added to the list of producing counties.

Nearly one-half of the granite production of 1907 was used for building and monumental purposes, amounting to \$432,913. This is an increase of \$57,839, as compared with the value, \$375,074, of the 1906 production.

There is given in the following table the uses and value of granite quarried from 1901 to 1907, inclusive:

USES OF GRANITE PRODUCED IN NORTH CAROLINA IN 1901-1907.

Uses.	1901.	1902.	1903.	1904.	1905.	1906.	1907.
Building and monumental purposes.....	\$108,574	\$167,639	\$127,486	\$75,632	\$312,362	\$375,074	\$432,913
Paving blocks.....	10,662	6,986	30,780	15,807	48,234	83,428	65,379
Curbing and flagging.....	56,245	82,615	68,099	101,632	74,307	138,080	66,967
Crushed stone for road-making, railroad ballast, etc.....	89,425	77,759	102,524	93,296	118,470	228,429	336,637
Other purposes.....		3,750	5,468	6,072	11,052	3,798	4,560
Total value.....	264,906	338,749	334,357	292,439	564,425	778,819	906,476

The next table gives the value of the granite produced from 1897 to 1907, inclusive, and shows very strikingly the remarkable growth of this industry in North Carolina:

PRODUCTION OF GRANITE IN NORTH CAROLINA, 1897 TO 1907.

Year.	Value.
1897.....	\$ 59,236
1898.....	79,969
1899.....	225,544
1900.....	257,962
1901.....	264,906
1902.....	338,749
1903.....	334,357
1904.....	292,439
1905.....	564,425
1906.....	778,819
1907.....	906,476

SANDSTONE.

PRODUCTION.

There was but little change to be noted in the sandstone industry in North Carolina during 1907. The production was small and was used largely for building purposes. The value of the production amounted to \$4,105, an increase of \$674, as compared with \$3,431, the value of the 1906 production. There is given in the following table the value of sandstone produced in the State for the years 1897 to 1907, inclusive:

PRODUCTION OF SANDSTONE IN NORTH
CAROLINA, 1897 TO 1907.

Year.	Value.
1897 -----	\$ 11,500
1898 -----	9,100
1899 -----	10,300
1900 -----	27,210
1901 -----	11,682
1902 -----	4,825
1903 -----	600
1904 -----	250
1905 -----	4,482
1906 -----	3,431
1907 -----	4,105

MARBLE AND OTHER FORMS OF LIMESTONE.

PRODUCTION.

The production of limestone in North Carolina is used for two purposes: for burning to lime and for road building, and the value of the production for each purpose is approximately the same. In 1907 the total value of the production of limestone was \$46,338, of which \$22,328 was the value of the limestone used for road building. The 1907 production was obtained from New Hanover, Buncombe, Henderson and Transylvania counties, given in the order of the value of their production. Considering the quantity of lime that is used in North Carolina for building purposes and as a fertilizer, there should be a much larger amount quarried in the State, but one of the main reasons against this is the high freight rates on the lime from the quarry to point of consumption.

Efforts are now being made to interest capital in the opening up of the marble quarries in Swain County. These are adjacent to the Murphy branch of the Southern Railway. The marble quarries of McDowell County, which are about 10 to 15 miles north of Marion and the same distance from the Southern Railway, will be in close proximity to railroad transportation when the new railroad that is being constructed from Tennessee to Marion is finished. These deposits of marble have been described in detail on pages 200 and 202 of Bulletin 2.

There is given in the following table the value of the production of limestone from 1901 to 1907, inclusive:

PRODUCTION OF MARBLE AND OTHER
FORMS OF LIMESTONE, 1901-1907.

Year.	Value.
1901.....	\$ 8,357
1902.....	23,153
1903.....	25,365
1904.....	19,887
1905.....	29,015
1906.....	72,051
1907.....	46,338

SAND AND GRAVEL.

The only figures given under this head are those that could be obtained in regard to sand or gravel used by moulders, and that reported as the production during 1907 was 3,205 tons, valued at \$2,191, as compared with 843 tons, valued at \$491, the production reported for 1906. This does not represent all the sand used for this purpose, as a considerable amount has been used by foundrymen, which they obtained close by their shops and kept no special record of the quantity or of its cost.

The quantity of sand that is used in the manufacture of mortar for brick and stone work can be roughly estimated by the amount of stone and brick used. Estimating this amount of sand at 1 ton per 1,000 brick, it would give, approximately, 250,000 tons of sand used for this purpose. Besides the above, there is a large amount of sand used in the manufacture of plaster of which it is almost impossible to give even an approximate estimate.

Another use for gravel and also crushed stone that is constantly increasing is in the manufacture of concrete. The use of this form of construction is rapidly growing in North Carolina.

There are, undoubtedly, in eastern North Carolina certain sands of sufficient purity that could be used in the manufacture of glass. One of the requisites of such sand is that it must not contain any elements that would give the slightest degree of color to the resulting glass. It is sometimes possible to commercially purify certain sands and make them adaptable for the manufacture of glass.

SAND-LIME BRICK.

In the report for 1905 there was given a rather complete description of sand-lime brick and their manufacture. The demand for these artificial bricks is increasing, and eastern North Carolina, with its large amount of available sand, offers some of the more favorable

opportunities for the manufacture of such brick. The production of these brick in the State during 1907 amounted to 4,823,000 brick, valued at \$38,808, of which 4,068,000 were common brick, valued at \$29,458, and 755,000 were front brick, valued at \$9,350. This production was made by three producers located in Scotland, New Hanover and Buncombe counties, given in the order of the value of their production. In the following table there is given the production of sand-lime brick in North Carolina for the past four years:

PRODUCTION OF SAND-LIME BRICK IN NORTH CAROLINA, 1904-1907.

Year.	Common Brick.		Front Brick.		Total Value.
	Number.	Value.	Number.	Value.	
1904-----	1,800,000	\$ 17,500	-----	\$-----	\$ 17,500
1905-----	3,185,000	20,953	660,000	8,150	29,103
1906-----	3,147,000	22,225	750,000	10,750	32,975
1907-----	4,068,000	29,458	755,000	9,350	38,808

CLAY.

Although there was a considerable increase in the production of clay products in North Carolina in 1907 as compared with the previous year, yet, considering the amount of fancy, pressed and vitrified brick, porcelain ware, pottery, earthen and stoneware and tiling, sewer pipe and terra cotta that are imported annually into the State, there is room for a much larger increase and development in the clay industry of the State. There is no doubt but that western North Carolina offers a very favorable location for a porcelain-ware manufacturing plant, inasmuch as there is produced each year in western North Carolina from \$75,000 to \$100,000 worth of kaolin of the porous variety, all of which is now being shipped out of the State. This would assure a supply of the finer grade of raw material, and other clays are abundant that would be suitable for other parts of the work; and then, again, there is water power available. Quartz and feldspar could also be obtained in western North Carolina, where there would be the additional advantage of being able to grind them by water power.

Taking all these conditions into consideration, it does seem as though such a manufacturing plant would be a most profitable investment.

Another branch of the clay product industry which is capable of much further development is the manufacture of a better quality of brick for general building purposes. There are being annually produced in North Carolina hundreds of thousands of common brick that will not stand transportation, and of course they bring but the lowest price per thousand in the market.

The total value of all clay products manufactured in North Carolina in 1907 amounted to \$1,316,308. If the value of the kaolin produced in the State during this time is added to this, it makes the total value of the clay industry in the State for 1907 amount to \$1,401,813. As compared with the value (\$1,272,796) of 1906, this is an increase of \$119,017.

KAOLIN.

PRODUCTION.

There was a falling off in the production of kaolin during 1907, due principally to the general trade depression of the latter six months of the year. Up to this time the demand for the kaolin had been better than the year before. The production during the year amounted to 11,035 pounds, valued at \$85,505. As compared with 11,803 tons, valued at \$90,036, the production of 1906, it is a decrease of 768 tons in quantity and of \$14,531 in value. If the trade conditions had been uniform throughout the year, the production of 1907 would have been much larger than that of the previous year. The average value per ton of the 1907 production was \$7.75, an increase of 12 cents, as compared with \$7.63, the average value received for the 1906 production. This kaolin was obtained from Jackson, Mitchell and Swain counties, the former being the larger producer. The Mitchell County deposits are on Bear Creek about one-half mile of Penland, a station on the South and Western Railroad, and began shipping ore in November, 1907.

POTTERY CLAY.

The decline noted in the pottery industry in North Carolina for the past year was continued in 1907, and the value of \$10,222 of the production for the year was a decrease of \$1,548, as compared with \$11,770, the value of the 1906 production. Although this production was small, it was divided amongst 25 manufacturers in the following 7 counties, given in the order of the importance of their production: Catawba, Buncombe, Randolph, Lincoln, Union, Wilkes and Johnston. Moore County, which was a producer in 1906, made no report of any production in 1907. Of this 1907 production, \$2,382 was the value of red earthenware and \$7,840 was the value of stoneware. In the following table there is given the value of the different grades of pottery produced in North Carolina in 1906 and 1907 by counties:

VALUE OF THE POTTERY PRODUCTS OF NORTH CAROLINA BY COUNTIES
IN 1905, 1906 AND 1907.

County.	1905.			1906.			1907.		
	Earthen-ware.	Stone-ware.	Total.	Earthen-ware.	Stone-ware.	Total.	Earthen-ware.	Stone-ware.	Total.
Buncombe-----	\$ 125	\$2,725	\$2,850	\$ 100	\$1,325	\$1,425	\$ 150	\$2,184	\$ 2,334
Catawba-----		1,930	1,930	135	4,600	4,735	1,392	1,800	3,192
Chatham-----		500	500						
Johnston-----	100	150	250	50	40	90	100		100
Lincoln-----	20	2,059	2,079		1,757	1,757	100	1,100	1,200
Moore-----		100	100	50	100	150			
Randolph-----		790	790	150	1,495	1,645	435	1,496	1,931
Union-----	100	2,400	2,500	178	740	918	165	750	915
Wilkes-----	42	2,278	2,320	30	1,000	1,030	40	510	550
Total-----	387	12,932	13,319	713	11,057	11,770	2,382	7,840	10,222

The next table shows the total value of the pottery produced in North Carolina from 1900 to 1907, inclusive:

PRODUCTION OF POTTERY IN NORTH
CAROLINA, 1900-1907.

Year.	Value of Pottery.
1900-----	\$ 18,863
1901-----	22,495
1902-----	14,512
1903-----	14,312
1904-----	13,900
1905-----	13,319
1906-----	11,770
1907-----	10,222

There is each year a small amount of pottery clay sold crude, and in 1907 this amounted to 193 tons, valued at \$143, and was obtained from Buncombe, Catawba, Lincoln and Randolph counties.

FIRE CLAY AND PIPE CLAY.

Under this head are included fire and pipe clays and the products manufactured from them, as fire brick, sewer pipe, drain tile, fancy tile, flue linings, terra cotta, etc. In 1907, the total value of all these products reported to the Survey office was \$146,033, this being an increase of \$25,068, as compared with \$120,965, the value of the 1906 production. Of the 1907 production, \$3,490 was for the value of 194,000 fire brick manufactured in Buncombe County, and 110 tons of fire clay, valued at \$543, obtained from Buncombe and Davidson counties. There is given in the following table the production of fire-clay and pipe-clay products from 1901 to 1907, inclusive, and shows the constant increase in the value of this industry during this time:

PRODUCT ON OF FIRE-CLAY AND PIPE-CLAY PRODUCTS IN NORTH CAROLINA,
1901-1907.

Year.	Fire Brick.		Sewer Pipe, Tile, Etc.	Crude Clay.	
	Quantity.	Value.		Tons.	Value.
1901	55,000	\$ 550	\$ 55,745		\$ 100
1902		1,203	72,618		215
1903	497,500	5,250	100,989	231	875
1904	163,000	2,700	110,800	80	700
1905	681,000	8,333	102,445	57	494
1906	401,000	7,180	113,900	19	185
1907	194,000	3,490	142,000	903	986

BRICK CLAY.

The production of common brick in North Carolina is dependent largely on the prosperity of the country, which determines to a certain extent the amount of building that will be carried on. There was a slight increase in the number of brick produced in North Carolina during 1907, and, with the exception of fire brick, the total number of brick manufactured amounted to 175,670,000, valued at \$1,159,610. This is an increase of 8,447,000 brick in quantity and of \$110,122 in value, as compared with 167,123,000 brick, valued at \$1,049,488, the production of 1906. There was a falling off in the production of brick in the latter half of the year, as compared with the first six months of 1907. Of this 1907 production, 174,750,000 were common brick, valued at \$1,150,185, which is an increase of 8,412,000 brick in quantity and of \$109,108 in value, as compared with 166,338,000 common brick, valued at \$1,041,078, the 1906 production. The average price received for the common brick in 1907 was \$6.58, which is 33 cents greater than the average value of 1906, which in turn was 42 cents greater than the average value received for the common brick of 1905. The lowest value per thousand reported as having been received for common brick during 1907 was \$3.50, which was the value reported for 200,000 brick in Iredell County. The highest value per thousand received for common brick was \$10, which was the value reported for 50,000 brick in Harnett County.

The number of pressed and fancy brick manufactured in 1907 was 770,000, valued at \$7,925, and of vitrified brick, 150,000, valued at \$1,500.

The table below shows the quantity and value of the common, pressed, vitrified and fire brick produced in North Carolina during the past four years:

PRODUCTION OF COMMON, PRESSED, VITRIFIED AND FIRE BRICK
IN 1904, 1905, 1906 AND 1907.

Character.	1904.		1905.		1906.		1907.	
	Quantity.	Value.	Quantity.	Value.	Quantity.	Value.	Quantity.	Value.
Common brick	143,988,850	\$795,494	153,610,000	\$896,289	166,338,000	\$1,041,078	174,750,000	\$1,150,185
Pressed brick	1,510,000	17,375	875,000	13,925	385,000	4,410	770,000	7,925
Vitrified brick	430,000	3,850	400,000	3,600	400,000	4,000	150,000	1,500
Fire brick----	163,000	2,700	681,000	8,333	401,000	7,180	194,000	3,490
Total----	146,091,850	819,419	155,566,000	922,147	167,524,000	1,056,668	175,864,000	1,163,100

The number of manufacturers engaged in making brick in 1907 was 192, which was 8 more than the number engaged in this business in 1906. There were 65 counties out of the 98 that made a production of brick in 1907, and of these Forsyth produced the largest number, amounting to 14,030,000 brick, valued at \$92,014. This county was also the largest producer in 1906, with a production of 14,277,000 brick, valued at \$82,796. By comparing the figures for the two years, it will be seen that there was a decided increase in the average value per thousand received for the 1907 production. The second largest producer in 1907 was Lenoir County, with a production of 8,950,000 brick, valued at \$55,875. Wayne County was third, with a production of 8,460,000. The county producing the smallest number of brick was Gates, with a production of 20,000 brick, valued at \$100.

There is given in the following tables the number and value of the different varieties of brick manufactured in North Carolina, by counties, for the years 1906 and 1907:

NUMBER AND VALUE OF BRICK MADE IN NORTH CAROLINA DURING
1906, BY COUNTIES.

County.	Common Brick.	Value.	Pressed Brick.	Value.	Vitrified and Fire Brick.	Value.
Alamance.....	3,858,000	\$ 25,650		\$.....		\$.....
Anson.....	500,000	3,000				
Beaufort.....	2,783,000	16,700				
Bertie.....	21,000	147				
Bladen.....	350,000	2,450				
Buncombe.....	5,271,000	35,350	100,000	1,500	388,000	6,980
Burke.....	1,710,000	8,551				
Caldwell.....	1,200,000	7,200				
Catawba.....	3,800,000	23,500				
Chatham.....	300,000	1,500				
Chowan.....	1,000,000	7,500				
Cleveland.....	1,249,000	7,711				
Columbus.....	2,250,000	14,000				
Craven.....	1,900,000	11,400				
Cumberland.....	4,700,000	27,750				
Davidson.....	2,900,000	18,000				
Davie.....	225,000	1,228				
Duplin.....	928,000	5,622				
Durham.....	7,450,000	49,850	60,000	600		
Edgecombe.....	7,230,000	44,800				
Forsyth.....	14,077,000	80,796	200,000	2,000		
Franklin.....	1,000,000	7,000				
Gaston.....	6,535,000	43,348				
Greene.....	700,000	4,700				
Guilford.....	8,550,000	54,605				
Halifax.....	5,650,000	33,800				
Harnett.....	500,000	3,900				
Haywood.....	300,000	2,400				
Henderson.....	2,000,000	11,000	25,000	250	*400,000	4,000
Iredell.....	3,350,000	21,100				
Jackson.....	16,000	100				
Johnston.....	3,500,000	23,400				
Lenoir.....	9,000,000	55,850				
Lincoln.....	800,000	5,600				
McDowell.....	333,000	2,000				
Macon.....	150,000	750				
Madison.....	200,000	900				
Martin.....	20,000	100				
Mecklenburg.....	5,650,000	37,500				
Moore.....	1,700,000	11,500				
Nash.....	1,950,000	13,750				
New Hanover.....	3,500,000	21,000				
Onslow.....	150,000	1,010				
Orange.....	550,000	3,175				
Pasquotank.....	2,100,000	13,650				
Pender.....	600,000	3,600				
Perquimans.....	300,000	2,100				
Pitt.....	1,488,000	9,901				
Randolph.....	1,717,000	10,452			13,000	300
Robeson.....	3,052,000	21,751				
Rockingham.....	1,950,000	12,730				
Rowan.....	3,550,000	24,300				
Rutherford.....	675,000	4,187				
Scotland.....	200,000	1,200				
Surry.....	6,700,000	39,000				
Union.....	3,057,000	18,288				
Wake.....	4,397,000	26,342				
Washington.....	183,000	1,100				
Wayne.....	10,720,000	63,413				
Wilkes.....	700,000	3,700				
Wilson.....	5,250,000	34,125				
Total.....	166,338,000	1,041,078	385,000	4,410	801,000	11,280

*Vitrified brick.

NUMBER AND VALUE OF BRICK MADE IN NORTH CAROLINA DURING
1907, BY COUNTIES.

County.	Common Brick.	Value.	Pressed Brick.	Value.	Vitrified and Fire Brick.	Value.
Alamance	5,715,000	\$ 38,325		\$		\$
Anson	500,000	3,500				
Beaufort	2,320,000	14,250				
Bertie	1,089,000	8,450				
Bladen	75,000	600				
Buncombe	2,443,000	15,521			194,000	3,490
Burke	1,450,000	7,000				
Cabarrus	5,010,000	37,500				
Caldwell	2,450,000	14,275				
Catawba	3,200,000	19,400				
Chatham	1,400,000	8,500				
Chowan	1,250,000	10,000				
Cleveland	1,060,000	6,980				
Columbus	2,166,000	16,000				
Craven	2,648,000	17,174				
Cumberland	3,765,000	24,365				
Davidson	700,000	5,600				
Davie	450,000	2,700				
Duplin	333,000	2,364				
Durham	6,520,000	44,057				
Edgecombe	3,150,000	21,650				
Forsyth	13,280,000	84,389	750,000	7,625		
Franklin	1,500,000	10,500				
Gaston	3,543,000	22,324				
Gates	20,000	100				
Granville	2,150,000	16,050				
Greene	500,000	4,000				
Guilford	6,620,000	41,245				
Halifax	6,550,000	44,800				
Harnett	400,000	2,800				
Henderson	6,500,000	42,500	20,000	300	150,000	1,500
Iredell	4,616,000	28,200				
Johnston	3,050,000	19,450				
Lee	150,000	850				
Lenoir	8,950,000	55,875				
Lincoln	2,127,000	14,002				
McDowell	183,000	1,100				
Macon	200,000	1,000				
Martin	95,000	670				
Mecklenburg	400,000	45,200				
Montgomery	800,000	5,000				
Moore	1,200,000	8,150				
Nash	4,000,000	28,000				
New Hanover	3,000,000	18,750				
Orange	535,000	3,913				
Pasquotank	2,200,000	14,275				
Pender	1,235,000	7,250				
Perquimans	200,000	1,400				
Person	300,000	2,400				
Pitt	2,150,000	15,000				
Randolph	3,305,000	18,708				
Robeson	1,227,000	8,350				
Rockingham	1,272,000	7,956				
Rowan	6,300,000	47,300				
Rutherford	1,272,000	7,956				
Scotland	50,000	500				
Stanly	233,000	1,400				
Stokes	145,000	1,049				
Surry	3,300,000	19,000				
Union	5,565,000	37,198				
Wake	6,240,000	41,515				
Wayne	8,460,000	51,500				
Wilkes	1,350,000	6,800				
Wilson	6,200,000	44,850				
Yadkin	80,000	560				
Total	174,750,000	1,150,185	770,000	7,925	344,000	4,990

In the next table are given the quantity and value of all the clay products produced in North Carolina for the years 1902 to 1907, inclusive:

VALUE OF CLAY PRODUCTIONS OF NORTH CAROLINA IN
1902, 1903, 1904, 1905, 1906 AND 1907.

	1902.		1903.		1904.	
	Quantity.	Value.	Quantity.	Value.	Quantity.	Value.
Common brick	131,611,700	\$694,827	136,822,900	\$731,802	143,988,850	\$ 795,494
Pressed brick	1,233,000	10,625	766,000	8,230	1,510,000	17,375
Vitrified brick	600,000	6,000	500,000	5,000	430,000	3,850
Fire brick	1,203	407,500	5,250	163,000	2,700	438
Earthenware	658		612		13,462	
Stoneware	13,854		13,700			
Decorated ware						
Sewer pipe, tile, etc.		72,618		100,989		110,800
	Tons.		Tons.		Tons.	
Kaolin	13,322	108,105	8,605	76,000	9,110	76,670
Fire clay		215	231	875	202*	761
Total value		908,105		942,458		1,021,530

	1905.		1906.		1907.	
	Quantity.	Value.	Quantity.	Value.	Quantity.	Value.
Common brick	153,610,000	\$896,289	166,338,000	\$1,041,078	174,750,000	\$1,150,185
Pressed brick	875,000	13,925	385,000	4,410	770,000	7,925
Vitrified brick	400,000	3,600	400,000	4,000	150,000	1,500
Fire brick	681,000	8,333	401,000	7,180	194,000	3,490
Earthenware		387		713		2,382
Stoneware		12,982		11,057		7,840
Decorated ware						
Sewer pipe, tile, etc.		102,445		113,900		142,000
	Tons.		Tons.		Tons.	
Kaolin	10,988	85,622	10,803	90,036	11,035	85,505
Fire clay	107*	519	207	322	903*	986
Total value		1,124,052		1,272,696		1,401,813

*Including ordinary stoneware clay sold crude.

As was stated last year, the statistics given in this table do not, perhaps, represent the total output of all the clay production of the State, for the reason that in some counties there are a few thousand brick made for local purposes regarding which it is extremely difficult or impossible to obtain statistics, this being especially true where the brick are not for sale, but are used directly by those manufacturing them.

SUMMARY.

In order to show more clearly the value of the mineral production of the State by counties, there is given in the table below the value of the productions in each county for the years 1906 and 1907. It will be seen from this table that 80 counties out of the 98 in the State made some mineral production:

VALUE OF MINERAL PRODUCTION BY COUNTIES IN NORTH CAROLINA
IN 1906 AND 1907.

County.	1906.			1907.		
	Mineral Production, Including Kaolin.	Clay Products, Except Kaolin.	Total.	Mineral Production, Including Kaolin.	Clay Products, Except Kaolin.	Total.
Alamance	\$	\$ 25,650	\$ 25,650	\$	\$ 38,325	\$ 38,325
Alexander	350		350	4,921		4,921
Alleghany	500		500	800		800
Anson		3,000	3,000	3,250	3,500	6,750
Ashe	4,970		4,970	2,750		2,750
Beaufort		17,300	17,300		14,250	14,250
Bertie		147	147		8,450	8,450
Bladen		2,450	2,450		600	600
Brunswick						
Buncombe	35,331	45,460	80,791	60,944	21,488	82,432
Burke	20,337	8,551	28,908	7,636	7,000	14,636
Cabarrus	24,742		24,742	1,322	37,560	39,082
Caldwell		7,200	7,200		14,275	14,275
Camden						
Carteret						
Caswell						
Catawba	10,418	28,280	38,698	6,455	22,617	29,072
Chatham		1,500	1,500	1,886	8,500	10,386
Cherokee	16,578		16,578	1,664		1,664
Chowan		7,500	7,500		10,000	10,000
Clay						
Cleveland	52,138	7,711	59,849	33,122	6,980	40,102
Columbus		14,000	14,000		16,000	16,000
Craven		11,400	11,400		17,174	17,174
Cumberland		27,750	27,750		24,365	24,365
Currituck						
Dare						
Davidson	1,355	18,000	19,355	6,304	6,050	12,354
Davie		1,238	1,238		2,700	2,700
Duplin		5,622	5,622		2,364	2,364
Durham		50,510	50,510		44,957	44,957
Edgecombe		44,800	44,800		21,650	21,650
Forsyth		82,796	82,796		92,014	92,014
Franklin	608	7,000	7,608	1,188	10,500	11,688
Gaston	1,844	43,348	45,192	4,650	22,324	26,974
Gates					100	100
Graham						
Granville	10,000		10,000	48,973	16,050	65,023
Greene		4,700	4,700		4,000	4,000
Guilford	6,603	167,677	174,280	7,441	183,545	190,986
Halifax		33,800	33,800		44,800	44,800
Harnett		3,900	3,900		2,800	2,800
Haywood	21,975	2,400	24,375	17,400		17,400
Henderson	48,207	15,250	63,517	11,463	44,300	55,763
Hertford						
Hyde						
Iredell	2,950	21,100	24,050	3,028	28,200	31,228
Jackson	60,995	100	91,035	90,940		90,940
Johnston		23,490	23,490		19,550	19,550
Jones						
Lenoir		55,850	55,850		55,875	55,875
Lincoln	6,810	7,357	13,667	6,500	15,265	21,765
McDowell	31,357	2,000	33,357	12,480	1,100	13,580
Macon	48,966	750	49,716	36,625	1,000	37,625
Madison	10,020	900	10,920	30,855		30,855
Martin		100	100		670	670
Mecklenburg	8,964	37,500	46,464	13,872	45,200	59,072
Mitchell	131,078		131,078	190,569		190,569
Montgomery	61,650		61,650	32,848	5,000	37,848
Moore	17,173	11,650	28,823	11,519	8,150	19,669
Nash	1,305	13,750	15,055	5,600	28,000	33,600
New Hanover	41,083	21,000	62,083	35,973	18,750	54,723
Northampton						
Onslow		1,010	1,010			
Orange	17,904	3,175	21,079	10,098	3,913	14,011
Pamlico						
Pasquotank		13,650	13,650		14,275	14,275
Pender		3,600	3,600		7,250	7,250
Perquimans		2,100	2,100		1,400	1,400
Person	56,779		56,779	30,973	2,400	33,373

VALUE OF MINERAL PRODUCTION BY COUNTIES—CONTINUED.

County.	1906.			1907.		
	Mineral Pro- duction, Including Kaolin.	Clay Products, Except Kaolin.	Total.	Mineral Pro- duction, Including Kaolin.	Clay Products, Except Kaolin.	Total.
Pitt.....	\$.....	\$ 9,909	\$ 9,909	\$.....	\$ 15,000	\$ 15,000
Polk.....	27,880		27,880	22,670		22,670
Randolph.....	7,500	12,617	20,117	300	20,704	21,004
Richmond.....	12		12			
Robeson.....		21,759	21,759		8,350	8,350
Rockingham.....	60,394	12,750	73,144	58,950	5,075	64,025
Rowan.....	447,753	24,500	472,053	475,269	47,300	522,569
Rutherford.....	25,110	4,187	29,297	17,659	7,956	25,615
Sampson.....						
Scotland.....	10,000	1,200	11,200	17,250	500	17,750
Stanly.....	10,150		10,150	50	1,400	1,450
Stokes.....	3,773		3,773	3,865	1,049	4,914
Surry.....	250,428	39,000	295,428	286,154	19,000	305,154
Swain.....	69,665		69,665	92,549		92,549
Transylvania.....	12,043		12,043	4,310		4,310
Tyrrell.....						
Union.....	5,035	19,203	24,241	521	38,113	38,634
Vance.....	13,100		13,100	8,400		8,400
Wake.....	475	26,342	26,817	5,478	41,515	46,993
Warren.....	23,653		23,653	46,478		46,478
Washington.....	916	1,100	1,100			
Watauga.....				30		30
Wayne.....	1,025	63,413	64,438	1,045	51,500	52,545
Wilkes.....	1,200	4,730	5,930	118	7,350	7,468
Wilson.....		34,125	34,125		44,850	44,850
Yadkin.....					560	560
Yancey.....	64,684		64,684	60,055		60,055
Unknown.....	1,575		1,575	2,014		2,014
Totals.....	1,824,941	1,182,660	3,009,601	1,857,414	1,316,308	3,173,722

As is seen from the above table, the following counties reported no production of mineral of any kind during 1907: Brunswick, Camden, Carteret, Caswell, Clay, Currituck, Dare, Graham, Hertford, Hyde, Jones, Northampton, Onslow, Pamlico, Richmond, Sampson, Tyrrell and Washington. Of these counties, the following reported a production in 1906: Onslow, Richmond and Washington. There were 2 counties, Gates and Yadkin, which reported a production in 1907, but not in 1906. There were only 52 counties of the 80 reporting a mineral production that reported anything besides clay products. Of the 65 counties reporting a production of clay, 29 counties did not report any other production. There were 11 counties reporting a mineral production which did not include any clay products.

The county whose mineral production, except clay products, was the largest was Rowan, with a value of \$475,269. Guilford County reported the greatest value of clay products, which was \$183,545. The county reporting the greatest value for its total mineral production in 1907 was Rowan, with a value of \$522,569. The lowest value reported by any county for its mineral production was \$30, in Watauga.



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